DOCUMENT RESUME

ED 056 749 PS 005 037

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TITLE Malnutrition and Mental Development: Implications for the Preschool Child: A Review of the Literature 1966-1970.
INSTITUTION Michigan Univ., Ann Arbor.
PUB DATE Jun 71
NOTE 119p.

EDRS PRICE MF-$0.65 HC-$6.58
DESCRIPTORS Behavior Development; *Cognitive Ability; *Early Childhood; Hunger; Intelligence; *Literature Reviews; *Mental Development; Mental Retardation; Neurological Defects; *Nutrition; Physical Development; Prenatal Influences; Sensory Integration

ABSTRACT

This document is the compilation of 50 reviews of selected articles, published between 1966-1970, pertaining to the relationship between malnutrition and potential to learn. The materials represent a relatively complete cross-section of the information available on this subject. There are three recurring themes in the publications reviewed. (1) If significant malnutrition occurs during critical periods of rapid brain cell multiplication, the number of cells produced is reduced. The cell deficiency is irreversible regardless of subsequent nutritional sufficiency. (2) Non-nutritional environmental factors may influence intersensory organization during periods of rapid development in a similar manner and might be more specifically described as the deprivation of positive perceived stimuli. (3) It seems that in the near future some governmental institution will assume major proportions of responsibility for a broad spectrum of children between the ages of 0-5 years. Since educators and educational institutions will share these responsibilities, the importance of all aspects of nurturance will become a paramount consideration. (Author/AJ)

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MALNUTRITION AND MENTAL DEVELOPMENT: IMPLICATIONS FOR THE PRESCHOOL CHILD

-A REVIEW OF THE LITERATURE 1966-1970-

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June, 1971

The accompanying materials include some fifty reviews of selected articles pertaining to the relationship between malnutrition and potential to learn. In each case the reviewed article was published within the time span from 1966- 1970. Although these materials are not entirely exhaustive of those available, they do represent a very broad and relatively complete cross-section.

There are several messages to educators which emerge repeatedly in these publications. These might be summarized in the following manner: (1) During the physical development of the brain specific periods of rapid cell multiplication for various areas of the brain may be identified. If significant malnutrition occurs during these critical growth periods the number of cells produced is reduced, in a degree corresponding to the severity of the malnutrition, and this reduction is irreversible regardless of subsequent nutritional sufficiency. This cellular deprivation appears to qualitatively influence the neurointegrative functioning potential of the brain. (2) Non-nutritional environmental factors may influence intersensory organization, during periods of rapid development, in a manner very similar to this and might be more specifically described as the deprivation of positive perceived stimuli. (3) The legislative barometer strongly suggests that in a relatively near future some governmental insitution or institutions will assume major proportions of responsibility for a broad spectrum of children within the age range of 0-5. It is reasonable to assume that education and educational institutions will be seen as the logical recipient of a significant share of these new responsibilities. The importance of all aspects of nurturance, in this new setting, will become a paramount consideration.

Several words of caution might reasonably be mentioned prior to reading the reviews: first, authors whose research are qualitatively commensurate to Cravioto, Winick and Gyorgy (to mention but a few) should not be reviewed. For those interested

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in the area of malnutrition and learning, complete reading is a must; and secondly, it will be noted that the quantity of data directly related to human experimentation is in very short supply. Extrapolation from animal experiments particularly in view of lack of uniformity in performance assessment leaves much to be desired,

Norm and Judy Keefer

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Children reared in poverty tend to do poorly on tests of intelligence. This is in part due to psychological and cultural factors but to a great extent it is the result of malnutrition in early childhood. It appears that millions of children in developing countries are experiencing some degree of retardation in learning because of inadequate nutrition and may also be occuring in the United States.

It is difficult to assess soley the dietary deficiencies in man but studies on animals and observations in developing countries provide substantial evidence. Animal experiments suggest that good nutrition during the first three years of life for humans is particularly important.

Usually lack of animal protein which contains the essential amino acids is the most serious problem. Even in the United States many who have adequate caloric intake primarily from low-cost foods may be malnourished. This has become of increasing concern to the federal government.

Desirable objectives of the United States food program are: 1. no one must go hungry; 2. hunger or malnutrition must not be a deterrent to economic development; and 3. the American diet must provide for optimum health throughout life.

Enough food can be provided but the consumer must choose to eat nourishing foods. This can in part be met by enriching commercial food products. In some areas, supplementary food packages are federally distributed to new and expectant mothers but a general education in the basic principles of nutrition is needed for continuing effort to assure that on one, especially no infant, fails to develop properly because of malnutrition.

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Though brief, this article is of particular interest because of its direct concern with malnutrition in the United States. The differentiation expressed between malnutrition due to inavailability of food in general and malnutrition due to choice of food is particulary important in this country where children are more likely to be malnourished due to the lack of needed nutrients in inexpensive and convenient foods purchased by the parents.

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Anonymous. "Malnutrition and Physical and Mental Development" Nutrition Review. Vol. 28, P. 176-177, July, 1970.

Numbrous studies have attempted to relate undernutrition during early life to later physical and mental development.

Retrospective studies define children who have been malnutritioned as compared to those who were not. (Stoch and Smythe, Cabak and Najdanvic) They are able to use large numbers of subjects in a relatively short time but contain a poor definition of the nutritional state during the critical period being examined. Controls must also be selected on the basis of nutritional history and may in themselves have been inadequately nourished (Garrow and Pike).

Prospective studies have fewer children but are evaluated nutritionally by the investigation (Cravioto and Robles). This offers better nutritional information and selection of controls at the time the study population is defined.

Both types of investigations suggest that under nutrition in early childhood may be associated with reduced height, cranial circumference, and motor and sensory development. Data suggests that in infants malnutrition under six months of age, impairment was most marked and recovery least likely.

Chase and Martin have attempted to study this problem in Denver, Colorado. They used the retrospective technique accompanied by it deficiencies. They found differences in weight, height and cranial circumference with children malnourished for more than four months. Even though this study has its flaws, it does point out that in the United States between 1965 and 1970, we have a large number of infants at risk.

This author attempts to portray an unbiased appraisal of the studies considered. Of particular interest is the Colorado study, since little research in the area is available pertaining to the United States.

Anonymous "Mental Development Following Kwashiorkor" Nutrition Review. Vol. 27, p. 46-49, February, 1969.

There has been a reduction in the mortality from kwashiorker and nutritional marasmus in many countries due to better treatment and a realization by the population that these diseases can be cured. As a result, there are many and an increasing number of children who have been cured and have lived to school age. However, to be separately considered are the huge number of persons who are survivors of mild to moderate degrees of protein-calorie malnutrition.

The most important studies to date on the effects of protein-calorie malnutrition in children on subsequent mental development have come from Africa, (Stock and Smythe) and Latin America (Cravioto and Robles). A study has also been completed in India (Champakam, Srikantia and Gopalan.)

An assessment of mental development is difficult in areas such as India where instruments used for mental functioning in one culture are not applicable in a different culture. Thus an essential part of the work consisted of the selection, standardization and validation of psychological tests. Although the children were school age, written and verbal tests were ruled out. Items were chosen to test different mental functions such as reasoning, organization of knowledge, memory and different perceptual processes. The authors go to great lengths to match children. The results show statistically significant differences in several parameters which makes these differences particularly impressive. The differences are especially marked in the youngest age group. The experimental children were more retarded in their perceptual and abstract ability than in their memory and verbal ability. They also scored more poorly in their performance on intersensory tests than did the control children. The mean heights and weights of the kwashiorker children were lower in every age group and in both sexes than the controls. This contrasts with the study of Stock and Smythe who found no difference in head circumference. This Indian study is important because it

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indicates marked differences in mental function between children who have suffered from kwashiorker compared with those from the same community who have not. These differences are wider than in most studies and exist 6 or more years after treatment of the disease where as work done in Mexico indicates mental recovery within a few months of clinical recovery.

A word of caution is necessary when drawing conclusions as there may be independent variables which act to produce both malnutrition and low intellegence, such as the hospitalization period of the experimental children, motivation of the parents, parental care and infectuous diseases.

High priority should be given to studies which separate the nutritional variable from genetic factors and environmental variables.

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The author suggests further study which eliminates other factors except malnutrition which may be affecting the results of research regarding the connection between the two. It is improbable that this can be done as it is important to maintain a humanistic approach to the study of man. We can't conduct studies with humans using animal research methods which is the only way, to date, for assuring no contamination of the study. Equally as important is the fact that if, in deed, malnutrition and environment are co-causes for the result of lower mental development, the two will have to be dealt with as inseparable.

Anonymous. "Pre-school Child Malnutrition: Primary Deterrent to Human Progress" Natl. Acad. Sc. - Natl. Res. Council. Publ. 1282. Ch. VII, Washington D. C., 1966.

General Summary:

The International Conference on Prevention of Malnutrition in the Pre-school Child established that: (1) Pre-school malnutrition is basically responsible for early deaths of millions of children. (1.a.) The fetus does have first priority on the mother's resources and will achieve normal birth weight and normal development at the expense of the mother. It is between the ages of one to four years that children in developing countries have a mortality rate 50-60 times higher than those in technically advanced areas. (2.) Of those who survive, pre-school malnutrition permanently impairs physical growth and probably causes irreversible mental and emotional damage. (2.a.) Conditions such as apathy, inattention and purposeless movements occur during the acute episode of protein - calorie malnutrition is without question, but it is uncertain whether mental ability, capacity, and behavior are irrevocably adversely affected. However the possibility is predicted due to the great dependancy of the brain upon protein synthesis and protein deficiency in experimental infant animals, has shown irreversible brain damage.

Major specific physical deficiencies and current programs for combatting childhood malnutrition and practical measures for improvement are summarized. The problems of malnutrition in the pre-school child are aggravated chiefly by three circumstances: (1) Mothers do not know what to feed their children to maintain normal growth and development. The conspicuous effects of malnutrition are attributed to other causes. They do not understand that small children need generous amounts of foods supplying high-quality proteins. (2) Many families cannot afford to buy the food required by children. Even if good foods are in

their hands, they are traded or sold for things desired by the adults. (3) Ill-advised crop practices, emphasis on the raising non-food cash crops, lack of transportation, lack of feed processing and preservation, all comspire to put the required foods beyond reach. Anthropological factors, social customs, superstitions, taboos, and religious beliefs also often operate to prevent giving children the foods they need.

Chapter VII
Cravioto, Joaquin. "Malnutrition and Behavioral Development in the Pre-school Child"

The author wonders about the permanent or transatory effects upon survivors of malnutrition in pre-industrialized areas. He points out studies with rats and cockerals in which the malnutrition influences subsequent development.

He also states, however, that even under severe food restriction the brain continues to grow in size and showing normal increments in nitrogen and phosphorus content. However other components remain static (sodium, potassium, chloride) and resemble amounts in a much younger animal. The author mentions several studies with malnutritioned animals that show retardation of biochemical indices of maturation. But he says the effects of malnutrition upon higher nervous function in humans has not been systematically evaluated, perhaps because infantile malnutrition has been mistakenly equated with poor socio - economic status. Among all families the qualtity of food given to the pre-school child is independent of the total available to the family. Traditional patterns of feeding sometimes prevent pre-school children from eating the more nutritious foods which are consumed by the adults and older children in the family.

Andriason and Makarychev, have confirmed their observations in children through animal experiments re-emphasizing the significant effects of the protein content of the diet on the functional status of the cerebral cortex, with both the

processes of internal inhibition and the intensity of positive reflex being affected.

The concern of research in areas where malnutrition is prevalent is to first determine whether malnourished children who have arrested somatic growth and biochemical maturation do have similar deceleration of mental development and whether the condition is transient or permanent.

Apathy is probably the most common finding in psychological disturbances accompanying kwashiorkor. This is so marked, that renewal of interest is considered one of the most obvious signs of improvement.

The author suggests that in considering Wilson's attempt to distinguish four kinds of apathy)primarily physiological; primarily psychological; "apathy" at the community level; and "apathy" as a characteristic of regional culture) that of the malnourished child could be of a mixed type or could be a sequel to emotional deprivation and loss produced by separation from the mother which is common at weaning in some societies, plus the separation that accompanies hospitalization. (However Menighelto points out the psychological changes accompanying malnutrition are present prior to hospitalization.)

In most communities where malnutrition is present, the child accompanies the mother everywhere she goes, prior to weaning. Also Geber and Dean observed that recovery is more rapid among infants whose mothers show the greatest interest and solicitude.

Also, although the physical signs of body wasting are more noticeable, the behavioral changes may have a greater importance because of their possible interference with cognitive development.

Sarrony, Engel, Valenzuela, Nelson and Dean, and deSilva have used electroencephalography as a method of assessment of neural function in severely malnourished

children. They showed atnormalities in the form, frequency and amplitude of the waves. Upon successful recovery of malnutrition, the children's electo-rencephalograms tended to conform more closely to the pattern of healthy children of similiar chronologic age. The speed of chagge was so rapid, according to Valenzuela, that all pathological features disappeared in no more than forty days.

Psychological Test Behavior

Mild-Moderate Forms of Malnutrition

Kugelmass, Poull, and Samual, in comparing the effects of nutritional improvement on mental performance in normal and mentally retarded children, found an average increase of 18 points in I.Q. of malnutrioned children in contrast with .9 change for the well-nourished group.

Stoch and Smythe, also found a similar increase in I.Q.'s of children in an all-day nursery who received adequate meals and vitamin supplements as compared to the control group.

Various studies in developing countries show newborn infants to be higher in psychomotor and adaptive development than in North American and European children. Soon after birth this declines, however, so that by 18-24 months of age, their performance is below their European counterparts. In six different countries, high correlations between deficits in height and weight and motor and adaptive developmental scores were found when Gesell's Developmental Quotients were used.

Severe Protein-Calorie Malnutrition

Cravioto and Robles found a direct relationship between rate of recovery of the initial deficit in relation to chronological age at admittance to hospitalization of third degree malnutritioned children. Dean points out that the progress in the first two weeks of treatment is of such magnitude that it is unlikely that the difference in the results of tests at the beginning and end of treatment could be

solely due to the extra care and attention received at the hospital.

Knobloch and Pasamonick conclude that motor development should be abandoned as prediction of later intellegence. It is suggested that the Gesell method is the area of behavior that can best serve this function since its concerned with organization of stimuli, the perception of interrelationships and the separation of the whole into its component parts, with subsequent resynthesis in a manner adequate to solve a new problem.

Thus low scores of performance in adaptive behavior in infants having suffered protein-calorie malnutrition before six months of age seem to indicate probable loss in intellectual potential.

As is supported by the findings of Farrea-Moncada, it is possible that the initial deficit in older children will completely disappear if other relevant factors don't interfere.

The author concludes by stating the relevance of the identification of an underlying pattern of psychological malfunctioning in malnutritioned children as it would assist in anticipating the child's developmental course, determine sources of his malfunctioning and establish curricular and other educational opportunities to permit optimal progress.

This article offers good identification and research material, but considering that it was done at a conference concerned with the prevention of malnutrition, little was offered here, at any rate, in terms of remediating the problem.

Anonymous, "Deadline for Saving Starved Infants."
Medical World News. Vol. 9:37; 1968, pg. 37

Dr. Myron Winick, a Cornell University pediatricion, has found the first direct evidence in humans that a low protein diet stunts the brain as it stunts the rest of the body. Furthermore, the damage done to the brain of a human infant may be irreversible if malnutrition occurs before six months of age.

These conclusions are based on analysis of brain DNA in experimental animals and infants who died accidentally or from protein starvation. Because DNA content of cells is constant for each species it is possible to determine the number of cells in a tissue sample by quantitating the DNA.

Malnutrition has been broadly induced in some developing countries by radical changes in social pattern without complimentary modifications occurring. In Chile, for example, the practice of breast feeding has been abandon on a national scale. Because of lack of sanitation, the babies' formulas frequently become contaminated and the infants get diarrhea. To stop the diarrhea, mothers feed their infants a mixture of flour and water. The gruel provides a poor cultural medium for bacteria, but even poorer food for babies.

In Santiago, Dr. Winick was able to study the brains of nine infants less than one year old who had died of marasmus, and compare them with the brains of 3 normally nourished U. S. and ten Chilean infants who died of accidental causes between 13 weeks gestation and one yer. By comparing the brain DNA content of the two groups he found a remarkable reduction in the number of brain cells in the undernourished groups.

The link between number of brain cells and intelligence has never been established but the bulk of the evidence suggests that this limited development has significant adverse effects on his subsequent adaptive behavior.

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Anonymous. "Prognosis for Malnourished Infants."
Nutritional Reviews, 25:11, 1967, pgs. 332-333.

"Mortality among a large number of severely malnourished children was increased when, on admission to hospital, the body weight deficit (compared with standard height and age tables) was large, dehydration was severe (especially with a reduced level of serum electrolytes), the liver was enlarged, and the serum bilirubin level was increased."

"Among 100 children admitted to the hospital during the winter of 1957, 20 per cent died despite administration of skim milk and, when necessary, saline solutions. There was no difference in age distribution among the children who died and those who survived. Most of the infants who died were 50 percent or more below the average weight for their age, while a similar degree of undernutrition was seen in 30 percent of the survivors."

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Anonymous. "The Developing Brain." Nature, Vol. 221, March 1, 1969, page 808.

Professor A. N. Davison has presented new evidence to suggest that there may be an intermediate stage in myelin synthesis. Thus crude myelin isolated from homogenates of the developing brain can be separated into two fractions--one comparable to mature myelin and other with a lipid composition similar to that of plasma and other cell membranes.

The process of myelination seems to be a "once and for All" event and once deposited around the axon most of the myelin seems to be melabolically rather stable. Myelination may therefore be regarded as a vulnerable period of development, for even mild undernutrition or aminoacid or hormonal imbalance can permanently reduce myelin deposition in the brain.

Much work is currently aimed at relating different protein spedies to the function of identifiable brain structures. M. K. Gaitonde drew attention to the complex and changging protein composition of the developing brain. With the introduction of quantitation of proteins separated by gel electrophoresis, it should become possible to extend considerably our knowledge of the role of proteins in the brain.

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Anonymous. "Underfeeding and Brain Development."
Nutritional Reviews; Vol. 20, No. 1, November 1967, page 332.

There is much interest today in possible nutritional influences on the mental performance of children. Undernourished children show, of course, a retardation in physical growth. The question is whether there is a comparable effect on psychomotor growth; and if such is the case, whether this might not account for some of the "backwardness" of the underprivileged peoples--a contribution to what has become known as the "culture of poverty." It is well known that deficiencies of certain vitamins--thiamine, niacin, phridoxine--can result in central nervous system symptoms.

Benton and Associates (1966) through experimentation in the deprivation of newborn rats demonstrated that there was a delay in the rate of chemical maturation of the brain during the period of underfeeding, but that this was largely overcome during the subsequent unrestricted phase.

The conclusions of Winick and Noble (1966), who used a similar model, differ from those of Benton. Winick found that the deficit in brain growth and DNA content on restricted intake was not repaired by subsequent ad libitum feeding when the dietary restrictions involved the early days of life, whereas it was godd good when the restriction took place in later periods. They concluded that early restriction showed the rate of cell multiplication while later restriction affected only cell size.

Additionally, the animal studies alluded to here refers only to diets which were restricted in amount, not in quality. Human children reared in underdeveloped areas often have a diet that is deficient both in quality and in quantity; and the former attribute may be fully as important as the latter, if not more so.

Anonymous. "Undernutrition in Children and Subsequent Brain Growth and Intellectual Development" Nutrition Review. Vol. 26, P. 197-199, July, 1968.

The studies with humans regarding the effect of malnutrition on mental development, have proved it incredibly difficult to separate the effects of malnutrition from those of other environmental factors and from possible genetic components.

Most research has been cross-sectional studies which don't provide an accurate picture of the child prior to entry into the study.

One of the few longetudinal studies in this area was begun by Stoch and Smythe (1955) in South Africa. It was based on the hypothesis that the ill effects of malnutrition are determined first by its occurrence during the period of maximum growth and second by the duration of undernutrition relative to the total period of growth.

The most grossly undernourished infants available were matched for age and sex with well nourished infants of the same population. Twenty children in each group have now been followed for 11 years. A great disparity was found in the living conditions of the two groups. The intelligence tests all showed significant differences between the two groups which is also supported by the lag of the experimental group in educational placement.

This study provides cumulative and impressive evidence that severe undernutrition during the first two years of life is associated with brain size and intellectual development.

Further studies need to look into the other factors which may effect retarded mental development along with malnutrition so that the actual contribution of malnutrion can be more accurately assessed.

Because of the obvious differences in environment between the experimental and control groups, there is a definite need for better longitudinal studies so that the filed (and the literature) is not so dppendant upon the Stoch and Smythe study which is quoted profusely.

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Ananymous. Nutritional Reviews, "Undernutrition and Development of the Central Nervous Systems in the Pig". Vol. 25, June 1967, pgs. 185-187.

One of the more significant gaps currently encumbering a good understanding of mentation is our lack of knowledge of the linkage of the brain and the spinal cord structure, central nervous system biochemistry, and observed species performance. Possibly the next step is to develope a model system in which one can study the effects of undernutrition on organ development.

Dickerson and Dobbing devised a system by which prenatal and postnatal growth and maturation of the pig's central nervous system could be measured by chemical means. Brain development and biochemical analysis was accomplished on animals of 65 days gestation and older. Changes in composition were expressed in terms of water, total nitrogen, total phosphate, DNA-P and cholesterol per kilogram of whole brain. This was done for the whole brain and for sections that were studied.

These results were used as the basis for a new assessment of central nervous systems development. Two phases of development were noted. Maturation was defined as a rapid increase in cellularity marked by increased levels of DNA-P. Growth, or myelination, was represented by increased cholesterol levels. The rate of maturation peaked prior to birth, whereas the rate of growth peaked shortly after parturition. The cerebellum and forebrains were thought to grow and mature at the same time, but not at the same rate. The cord matured early, but continued to grow for at least 34 weeks.

In experiments with undernourished and control pigs the brain and cord of the undernourished animals grew at a subnormal rate. The length of the cord was restricted by slow body growth by the thickness was unaffected. Lower DNA-P concentration and high percentages of cholesterol indicated that considerable brain develop-

ment occurred during the period of undernutrition, but tissues were far less mature in normal animals.

No attempts were made to evaluate functional performance of the central nervous systems. More information might be obtained by comparing growth rates in smaller portions of the brains, such as the hypothalamus, temporal cortex, and basal ganglia.

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Bakan, Rita. "Malnutrition and Learning" Kappan. Vol. LI, No. 10 June, 1970.

The purpose of this paper is to present some of the evidence, based on animal and human studies, linking malnutrition to the growth of the brain, the performance of various intellectual functions, and other developmental variables related to learning.

Brain Development and Function

Undernutrition of pigs and rats from birth to 21 days produces a persistent and permanent reduction in brain weight. The earlier the malnutrition the more severe is the effect and less likely is recovery. Under-nutrition also results in specific degeration within brain cells; again, the earlier the restriction, the more severe the damage.

The effects of postnatal malnutrition on animals who have already suffered prenatal malnutrition are more marked than effects of either prenatal or postnatal deprivation separately. It seems that prenatal malnutrition made these animals more susceptible to postnatal undernutrition. If the deprivation occurs early in infancy, these changes are irreversible, while the effects of later deprivation may be reversed through proper feeding. Another finding is that poor nutrition of the infant female may affect the development of her offspring many years later.

Available evidence from human studies reinforces the findings of experiments with animals and suggests that early infancy is a critical period for the development of the brain. This is also the time when the brain is extremely vulnerable to the effects of malnutrition. Indirect measurements of the brain growth in humans shows that malnutrition will curtail the normal rate of increase in head circumference, which accurately reflects the reduced

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number of cells present in their brain. When a fluid, similar to spinal fluid is used to fill the cavity between the brain and the skull, and a diffused light is used to make the fluid glow, a very small are in shown with normal children. But malnutritioned children's entire brain case glows, from the forehead to the back of the head.

What is the relationship of these changes in brain development to behavior and to intelligence?

Follow-up tests of children restored to health showed that they achieved lower schores than children who had not suffered from malnutrition. Similarly, the malnourished children studied by Stoch and Smythe who exhibited reduced head circumference had lower I. Q.'s even after long-term follow-up.

A series of studies by Cravioto and his associates in Mexico and Quatemalla has shown that performance of children on psychological tests was related to nutritional factors, not to differences in personal hygiene, housing, cash income, or other social and economic variables. Children exposed to severe early malnutrition exhibited perceptual defects as well as smaller body size. The earlier the malnutrition, the more profound the psychological retardation. The most severe retardation occured in children admitted to the hospital under six months of age and did not improve on tests even after 220 days of treatment. Those admitted later, with the same socioeconomic background and the same severe malnutrition but a different time of onset, did recover after prolonged rehabilitation.

Evidence already exists that the lag in the development of certain varieties of intersensory integration has a high correlation with backwardness in learning to read.

In addition to the negative impact of malnutrition on the growth rates and intersensory development of children, Cravioto found a relationship be-

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tween these aspects of development and infection. Eichenwald has shown that certain infections in malnourished children may produce severe and prolonged hypoglycemia, a condition which can by itself cause brain damage. In addition, various biochemical defects of children with malnutrition are accentuated by infection. Infection and malnutrition thus act synergistically to produce a chronically and recurrently sick child less likely to react to sensory stimuli from his already inadequate social environment.

Effects of Prenatal Nutrition

Since it has been found that both low birth weight and a high infant mortality rate are more common in poor families, the finding that undernutrition appears to be the cause of prenatal growth retardation is an important one. In addition to being 15 percent smaller, the infants from poor families had multiple evidences, in terms of relative weight of such organs as the thymus, spleen, liver, etc. of prenatal undernutrition. The offspring of non-poor families had a mean thymus weight which was 104 percent of the "normal" weight, while the poor infants had a mean thymus weight of only 66 percent of "normal." While the function of the thymus is not yet completely understood, there is increasing evidence that it is involved in both growth, and immunological functions. Children whose mothers received a vitamin supplement during pregnancy had a significantly higher I. Q. at three and four years of age than did children whose mother received placebos. Also, when a vitamin supplement was given to pregnant and lactating women with poor nutritional environment, the offspring at four years had an average I. Q. score eight points greater than the average score of children of mothers given a placebo over the same period.

Nutritional Therapy and I. Q.

Kuglemass demonstrated an increase in the I. Q. of both retarded and

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mentally normal children as a result of prolonged nutritional rehabilitation. The malnourished retarded children showed a gain of 10 points and the normal children one of 18 points after a period of dietary improvement. In contrast, there was relatively little change in the scores of the well-nourished retarded and normal children.

Coursin has shown that deficiencies in the B-complex vitamins and in vitamin C can produce adnormalities of nerve cell metabolism and function and can impair mental development. Vitamin therapy has effected improved mental functioning with such children.

Motivation and Personality Changes

One of the first effects of malnutrition is a reduction of the child's responsiveness to stimulation and the emergence of various degrees of apathy. Apathetic behavior in its turn can function to reduce the value of the child as a stimulus and to diminish the adult's responsiveness to him. Thus apathy can provoke apathy and so contribute to a cumulative pattern of reduced adult-child interaction.

There is evidence that if malnutrition occurs after a certain age its effects on learning are reversible. Though the exact nature of the timing is yet to be worked out, it is becoming clear that the prenatal period and the first six months of life are critical.

The author suggests the following methods for insuring that every child has the same chance of being "created equal": 1) convey the vital importance of prenatal and early infant nutrition to girls in school, 2) providing all school children with high quality breakfasts and lunches (malnutrition is increasing regardless of social class) 3) educate the public regrading nutrition and seeing that food is made more readily available to those in real need.

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The earlier we provide preschool for children, the sooner we would have the facility for good nutritional dispersement. The inclusion of a breakfast and lunch would seem a reasonable and necessary investment in the maximized development of children's mental function.

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Bailit, Howard, and Whelan, Mary Anne. "Some Factors Related to Size and Intelligence in an Institutionalized Mentally Retarded Population" J. of Pediatrics. P. 897-909, July-December, 1967.

A sample of 77 institutionalized children diagnosed as mentally retarded without other neurological signs or symptoms (familial-cultural)retardates) was examined anthropometrically as well as for I. Q., birthweight, parental age, birth order, age at admission, and length of time spent in the institution.

The results indicate that: (1) The sample subjects were retarded for all eleven measurements when compared to published standards of Caucasian Philodelphia children. Height, lead length, and biocranial and bi-iliac diameters were most reduced; approximately 25 or 40 percent of the subjects were two or more standard deviations below the normal population mean for these dimensions. The remaining measurements were much less depressed, ranging from 5 to 20 percent below the mean. (2) It is not known if the anthropometric values of this study are representative of familial retardation in general. Compared to studies of children with Down's syndrome, the familial retardates are considerably taller. (3) While boys were relatively smaller than girls in all measurements, the differences were not significant. (4) Leg length was disproportionately reduced compared to sitting height. (5) Parity, parental age at birth, and birth weight were not remarkable. (6) I. Q. and size were independent within the sample. (7) No relationship was found among parity, parental age at birth, and I. Q. and size. (8) Birth weight was significantly and positively correlated in 6 to 11 measurements and the other five approached significance. Those heavier at birth were larger and more intelligent. (9) Length of time spent in the institution was not found to influence growth or I. Q. (10) There was no evidence for a progressive retardation in growth or intelligence with increasing age relative to normal standards.

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Interestingly, in the body of this report, the researchers are quoted as follows, "paternal age is significantly and positively correlated with I. Q. We have no ready explanation for this finding and to our knowledge, it has not been demonstrated elsewhere. It is probably a chance occurrence." One wonders why, if paternal age is so correlated, that the information is so easily dismissed. No mention is made in the summary.

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Barnes, Richard; Cunnold, Susan; Limmermann, Robert; Simmons, Howard; McLeod Robert and Krook, Sennart. "Influence of Nutritional Deprivations in Early Life on Learning Behavior of Rats as Measured by Performance in a Water Maze." Journal of Nutrition, 89:1966, pgs. 399-409.

Learning behavior was studied in rats that were subjected to different forms of nutritional deprivation early in life. Food deprivation during the first three weeks of life was achieved by increasing the number of rat pups nursing from one lactating female. At three weeks of age rats were weaned and some fed an extremely low protein diet for eight weeks. Four treatment groups were established by subjecting rats to either of these nutritional deprivations alone or by combining the two forms of restrictions or by providing optional nutrition from birth. When the rats were from six to nine months of age, visual discrimination performance in a Y water maze was measured. Male rats that were deprived both before and after weaning made significantly more errors than the normal controls. The animals that were deprived preweaning or post-weaning alone gave intermediate results. No significant differences were obtained among female rats subjected to the same treatment regimens. The conclusion has been drawn that nutritional deprivation in early life can cause a long-lasting, possibly permanent retardation in the development of learning behavior. Motivational or emotional behavioral differences were noted among the treatment groups and therefore the realtive contribution of "drive" as contrasted with "capacity" in the altered learning behavior is not known. When rats were tested for position reversal performance in the water maze shortly after weaning and during the time that certain groups were receiving the severely protein-deficient diet, the most errors were made by the double-deprived rats, followed closely by those that were malnourished only after weaning. Rats that had been restricted prior to weaning only or the normal controls made the fewest errors.

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Female rats showed less definite effect of dietary treatment on performance than the males.

In both procedure and interpretation this report represents one of the more responsible contributions in this area of consideration. To the reviewer's knowledge, these authors are the first to suggest the possibility of discrimination by sex in the effects of malnutrition. And, though not the first, this report is quite thorough in incorporating into their work a qualification of the data due to the possible contamination of unfactored social motivational indics. In both these considerations the authors suggest that a more sensitive test of learning behavior must be used and, since small differences are to be anticipated, it is probable that very large groups of animals must be used.

This must be regarded as one of the best efforts to date and certainly worthy of replication with larger animal populations.

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Barnes, Richard H. "Experimental Animal Approaches to the Study of Early Malnutrition and Mental Development" Federation Proceedings. Vol. 26, P. 144-147, 1967.

Experimental animal studies dealing with the effects of nutrition in early life upon adult learning behavior have been disappointing in number and interpretive value. The major difficulty has been a lack of nutrition knowledge on the part of the experimental psychologists who have conducted studies and a lack of knowledge of experimental psychology on the part of nutritionists engaging in such work. A cooperative effort on the part of the two disciplines is needed.

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Studies by experimental psychologists have shown an increased drive for food or water if the animals are not satiated at the time of testing. This drive for food or water is lessened or disappears if the deprivation had been initiated 12 days or more after weaning. In investigations by Branfenbrenner, the conclusion was drawn that the drive deprivation rather than altered learning capacity enhanced the animals' general activity level and its ability to solve drive-relevant problems. Those adult rats experiencing feeding frustration (by increasing the litters being nursed by a female) were more successful in competition for food and hoarded significantly more pellets that normal control rats. Griffiths and Senter reported that maze performance by rats receiving a protein free diet were superior in a maze performance to rats being fed a protein-rich diet when the protein rich diet was being used for reinforcement. A study by Andriason noted that when the regular diet and the reward diet were the same, there were no demonstrable differences between low protein-fed and normal protein-fed rats in maze performance.

Cowley and Griesel, found a highly significant difference in scores on the Hebb-Williams dry maze between first filial generation deprived male rats and the control group. There was no difference with the female deprived rats. The author suggests that the results may in part be due to maternal deprevation,

but perhaps the rats on the high protein diet have increased drive which lead to their better performance.

Neither Bernhardt who used casein, nor Pilgrim who used protein, noted any differences in the performance of two groups of rats, one deprived, the other not, on the water maze.

Restriction of food intake, either prior to weaning or immediately following weaning, appears to have some long-lasting effect on the animal's behavioral pattern. These behavioral changes have been described as reflections of drive deprivations due to withdrawal of food and not as nutritional deficiences resulting in altered learning behavior. There have been no significant effects upon learning behavior following rehabilitation shown with animals who have been fed protein deficient diets for short periods of time after weaning.

The interdisciplinary efforts of psychologists, pathologists and nutritionists at Cornell University showed that baby pigs evidenced several of the classic signs of kwashiorker after being on a diet for eight weeks containing 3% protein, and 24% fat along with the other nutrients in adequate quantities. After they were rehabilitated with a diet of 25% casein and 10% fat, they did not achieve the body weight of the control animals. Also it was found that the experimental pigs needed a greatly prolonged period of trails when attempting to extinguish a well-established conditioned response as compared to the controls, even though there had been no difference in speed of development of the conditioned response between the two groups.

As to rats, on the basis of additional evidence from current research involving different types of test procedures, it is believed that early nutritional deprivations have resulted in a decreased learning capacity as well as changes in other behavioral characteristics. The general conclusion has been

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proposed that nutritional deprivations in early life can affect learning behavior in the nutritionally rehabilitated adult male rat. Results indicate that behavioral differences do develop in the female, but they are much less definative and it is possible they are not as lasting as in the males.

Some of these studies give encouragement to the conduct of more extensive investigations. They are especially needed with slower growing animals such as primates in order to bridge the span from rat to man. The possibility also exists that some degree of mental retardation may result from relatively mild undernutrition imposed in early life.

The author makes his point as to the need for cooperating studies between the disciplines in the form of the conflicting array of studies which he presents. Unfortunately he leaves it to his reader to presume the rational, since their presentation is disjointed. His point, however, it well taken. One other good point which is made and has not been suggested by other authors with which this writer is familiar, it that studies using primates may well be more relevant for humans.

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Barnes, Richard, Moore, Ulric, and Pond, Wilson, "Behavioral Abnormalities in Young Adult Pigs Caused by Malnutrition in Early Life" J. Nutrition. Vol. 100, p. 149-155, 1970.

Baby pigs were malnourished for a period of eight weeks by restricting protein or calorie intake with the objective of studying behavioral changes that remained long after nutritional rehabilitation had been achieved. An apparatus was designed for the measurement of changes in the level of excitement or emotionality under conditions of stress, as well as changes in learning performance in a conditioned avoidance situation. The most striking behavioral change due to early malnutrition was the heightened excitement of the pigs when exposed to aversive stimuli, although there was also an indication of decreased learning ability. Since learning performance can be affected by behavioral factors that influence the level of reinforcement (reward or punishment), impaired learning may be due either to decreased intelligence (capacity) or to elevated excitement and consequent over-reaction to reinforcement. The nutritional condition which caused the greatest change in behavioral development resulted from feeding a diet very low in protein from the third through the 11th week of life. Behavioral abnormalities were also noted, although in lesser degree, if the low protein diet was initiated later, i.e., seventh to fifteenth week of life or if a diet of normal composition was fed in restricted quantity so as to prevent growth during an eight week period starting either at birth or at three weeks of age.

During the depletion period the pigs which were either protein or calorie deprived developed a gaunt, unthrifty appearance. The protein-depleted animals consumed very little food while the calorie-depleted pigs retained their appetite. Surprisingly these pigs remained active throughout the eight weeks of

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depletion and when let out of their pens each morning during the clean-up period they frolicked and explored the new surroundings much in the same manner as the control animals. Other studies have suggested great loss of motor control is significant to the results of these evaluations it would seem necessary to œvolve standard test procedures.

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Benton, John; Moser, Hugo; Doege, Philip and Carr, Sheila. "Modification of the Schedule of Myelination in the Rat by Early Mutritional Depreivation." Pediatrics. Vol. 38, No. 5, November 1966.

Relative nutritional deprivation was produced in groups of 16 to 21 newborn rats who were all nursed by one rat (deprived gro up) and compared with control litters containing 10 or less animals. Both groups were weaned at 21 days and thereafter allowed an unlimited supply of food.

There was diminished somatic growth in all of the deprived groups and, at 2 and 3 weeks, the wight of many of the deprived animals was approximately one-half that of the controls. Brain weight, total brain lipids, cholesterol and phospholipids were reduced to approximately 80% of the control. Brain cerebrosides were affected to a greater extent than the other lipids, being only fifty percent of the control values. Histological sections showed less myelin. At six weeks, following three weeks of ad lib. food intake, the body weight, brain weight, and concentrations of the brain lipids of the imitially deprived animals were essentially equal to those in the control animals.

The delivery of this report by Benton and his associates must have, at least initially, caused quite a stir among those concerned with malnutrition and brain development since it appears to radically differ (in terms of rejuvenation potential) with the vast majority of their introductions.

It is assumed by the reviewer that the suggested difference may eventually lead to a reconsideration of the limits of the "critical growth periods" often alluded to in brain development. Some variance in definition, as might be reasonably expected, presently appears in the literature. Benton, et.al., pin-points the maximum rate of synthesis of myelin lipids taking place on the fifteenth and sixteenth day after birth (in rats). Daveson (1962) suggests

the same growth period to extend from 10 to 21 days of age. Since the studies generally discontinue deprivation at the 21 day of life in the rat this may encourage an actual periodic extension of the synthesizing mechanisms involved.

Until these variances are further understood and explained, extrapolation of data to human counterparts will be subject to considerably more question than even exists presently.

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Botha-Antoun, E., Babayan, S., and Harfouche, J. K. "Intellectual Development Related to Nutritional Status" The Journal of Tropical Pediatrics., p. 113-115, September, 1968.

In view of the knowledge that the greatest effects of undernutrition in early childhood an mental physical development may be produced at periods of maximal growth and the fact that most brain growth and much mental development take place in the first two years of life, it is probable that adverse effects on mental functioning during that period will not disappear as a consequence of later adequare diets. This study looks at the relationship of low nutritional status in the first 18 months of life to intellectual performance at age 4-5 years.

Subjects and control group were 44 children each with matched parents in terms of age, intellectual performance, and educational level. All were born healthy and were not malnutritioned until at least three months after birth (when the mother started weaning the child).

Results:

The mean I. Q. of the experimental group was 79.5 and that of the control group was 103. The mean age of onset of walking for the experimental group: 13.5 months, for the control group: 11.8 months; talking for the experimental group: 16.7 months, for the control group: 14.4 - all were statistically significant.

This article suggests that the children were not malnourished until onset of weaning, as do others. However, there appears to be a controversy, the other view being that the child is malnourished prenatally as well. It would be of interest to note if any of the parents of either group had experienced malnutrition in early life.

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Carter, James and Associates. "Health and Nutrition in Disadvantaged Children and Their Relationship with Intellectual Development." Demonstration and Radearch Center for Early Education and Vanderhill University School of Medicine, pgs. 1-67

Three groups of children were studied in terms of physical status as related to intellectual adequacy as measured by the Stanford-Benet or W. P. P. S. I.

Each group contained about 17 children. Subjects were selected on the following basis: Socioeconomic status, mother under 35 years of age, subject should not be farther in the family than the third child, and younger siblings should be present. The possibility of the child attending pre-school was presented to the families. Twenty families who met the criteria were selected as the control group.

Priorities for each of the three programs were determined by questionaires answered by the families.

Vision, hearing and speech evaluations were conducted, the results of which are included.

Nutrition

At the rural and urban centers the children were served a snack and a lunch while children in the urban center also received breakfast.

A composite specimen analysis regarding the nutrients consumed by "poor eaters," "average eaters", and "big eaters" was conducted. A modified seven day recall dietary history was obrained from each mother by an experienced dietitian. The estimated daily intakes of nutrients were found to be well above reference standards.

A medical history for each child was also completed with the results found to be within normal limits-although the children tended to be shorter and weight less than those indicated by the Iowa Norms. Also amounts of subcutaneous fat

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Dental Findings

The proportion of children with all existing teeth normal is twice as great in the urban group as in the rural group. Water samples from homes were analyzed in an effort to determine the source of the dental differences and fluoridation apparent to make the difference.

Biochemical Determination

Blood specimens were collected from the children from which it was determined that the few who had low or deficient levels of hemoglobin were in the urban group. Substantial amount of vitamin A deficiency were found in all three groups. There were no deficiencies found in vitamin C. There was more anemia and systemic iron deficiency in the urban group than in the rural groups. School feeding programs seemed to be a main contributor to the adequate parameters found.

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Examination for Ova and Parasites

Using a scotch tape swab and a stool examination, it was found that several children intthe urban group had Ascaris and Trichuris ova and Giardia cysts in their stools. Half the urban children were infected with pinworm as well as about 70% of the rural children.

Relationships Among Variables

There was found a correlation between the mother's height and her child's birth weight, adjusted weight, and adjusted height. There was no correlation between each of these variables and the Benet I.Q. score.

The thorough nature of this study is most promising. There appears to be one flaw in regard to the examination of nutrition and the preschool subject--it would seem that there should be a more reliable means than weekly recall on the

of the mother for determining food intake by the children.

It would be benifical to expand such studies to larger populations.

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Champakam, S. and Srikantia, S. G. and Gopalan, C. "Kwashiorkor and Mental Development" Amer. J. Clin. Nutr. Vol 21: p. 844-852, August, 1968.

This study was concerned with: (1) evolving suitable tests of mental development for children in the Telengana area of Andhra Pradesh, India, taking into consideration the two languages spoken and the varied cultural environments of the two linguistic groups. Suitable tests were developed for six through 11 years olds and included intelligence tests and sensory development tests; (2) the application of these tests to children who had recovered from kwashiorker and to "normal" children in the community.

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Development of Tests:

Due to lack of reading and writing ability, the I.Q. tests had to be based on the actual manipulation of varied concrete materials by the subjects. (They were also individually applied to the subject.) The test items were so chosen as to test different mental functions like reasoning, organization of knowledge, memory and different perceptual processes. The test was standardized by a population belonging to the same cultural and socioeconomic class as the subjects with kwashiorker.

The sensory development tests were presented through three sets of comparative judging tasks: visual-haptic series, visual-kinesthetic series and haptic-series.

Application of Tests:

Nineteen children who had been admitted to the hospital with kwashiorker and had been successfully treated were the experimental group. All were between 18 and 36 months at the time of admission. The follow-up assessment occurred when they were between eight and 11 years of age.

Selection of Control Subjects:

Three control children, matched in age, sex religion, cast, socioeconomic

status, family size, birth order and educational background of parents, general pattern of care, from the same locality, in the same school and class were compared to each child in the experimental group.

Results and Conclusion:

There was a significant difference between the control subjects and those treated for kwashiorkor on the I.Q. tests. It was most significant in the younger children (8-9 years of age) and tended to diminish in the older children (ten - eleven years of age). Also there was a close direct relationship between the intelligence scores and the performance in the intersensory tests - both in experimental and control groups. It was poorer in the younger group and tended to improve in the older group.

The retardation was noticable mainly with regard to perceptual and abstract abilities.

Even so, it is difficult to assess the extent to which the kwashiorker was the basis for lower intelligence scores or whether factors of individual initiative on the part of parents in providing for their children, or immobilization during illness may contribute.

The authors offer an admirable attempt to match the experimental and control groups. Even with such an attempt, they are temporing their results in the light of such unmeasurable factors as parental individaul initiative. It would be of interest to do a longitudinal study using this type of population in which children admitted to a hospital with kwashiorker were given concentrated attention in an effort to develop their mental processes, another such group wąs not worked with, and a third group, contained in the hospital for other reasons than kwashiorker were compared to normal population.

Coursin, David. "Relationship of Nutrition to Central Nervous System Development and Function". Federation Proceedings. Vol. 26: pgs. 134-138. 1967

Nutritionally induced errors in metabolism are capable of causing central nervous system dysfunction. A constantly growing list of recognized metabolic abnormalities would include the carbohydrates (hyperglycemia of diabetes, hypoglycemia, and galactosemia); lipids (xanthomatoses, cerebrosides, gangliosides); and the amine acids (Phenylalanine, branched chain forms, arginine, glycine, lypine, methionine, tyrosine, and histidine). The specific deficiencies include vitamins A, B_1, B_2, B_6, B_{12}, iodine and others.

Additionally, there are now numerous projects under way to explore a lost of variables in the broad field of the relationships of macromolecules to mental processes.

Available information and planned research support the thesis that with the exclusion of the insults of anoxia, disease and trouma, central nervous system development and performance basically stems from the biochemistry of the nerve cells. Furthermore, the metabolism of these cells, their structural components, energy kinetics and integrity of function are fundamentally related to their nutrition over a time continuum.

Early and prolonged undernutrition may result in many compensatory adaptations of intracellular metabolism. These may alter the usual course of events, resulting in limitations or retardation of nervous system performance. The term retardation implies a spectrum of limitations that is qualitative as to the degree of severity of their dysfunction.

In developing countries where statistics indicate that some 75% of preschool children are under nourished a very high morbidity and mortality rate results. Those who survive are not to be construed as "the fittest", but rather are the ones who have managed to sustain life despite their marginal dietary subsistence, persistent parasitie infestations, and recurrent infections.

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In response to this future research needs a full scale multidisciplinary attache on the numerous facets of nutrition affecting brain function. Included must be:

(1) The development of improved techniques for identifying and quantitating types and degrees of biochemical abnormalities that occur in mild, moderate, and severe undernutrition.

(2) The continued exploration of molecular components of the brain cell that relate to mentation.

(3) The development of more meaningful procedures for determingng brain function on a conceptual basis with consideration of family background, environmental circumstances, and cultural factors.

(4) Devising better techniques for measuring neurophysiological mechanisms and their integration in the total functioning complex of the individual.

(5) Meeting the demands for appropriate nutritional resources and logistics for resolving the problems that confront the preschool child.

In In addition to the above the author has included one of the better synthesis of Dr. Crevioto's work among the Cakchiquel Indians in Guatemala.

This was a very informative and "full" article. As it initially stated this is an "overview" of the current position relative to malnutrition.

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Cravioto, Janquin and DeLecardie, Elsa and Birch, Herbert. "Nutrition, Growth and Neurointegrative Development: An Experimental and Ecologic Study". Pediatrics, Vol. 38, No. 2, Part II, August 1966, pags. 319-361

This study is concerned with the effects of protein-calorie malnutrition and the affects of the deprivation on stature, weight and the capacity to learn. If the relationships suggested above is actually the case, then the significance of observable and dramatic consequences of malnutrition for physical statuse may be but one visible sign of functionally, perhaps, far more important non-visible handicapping.

The basic hypothesis being specifically explored is that serious degrees of malnutrition either of primary or secondary causation during the preschool years can interfere with central nervous system development and result in a reduced level of adaptive capacity.

Prior work by Coursin suggested to the author that at least three broad areas of inquiry justified extensive research. These are:

1) The exploration of molecular components operating in the brain cellaas they relate to mentation;

2) The development of more meaningful procedures for measuring brain function on a conceptual basis, with consideration of family background, environmental circumstances and cultural factors; and

3) Devising better techniques for measuring neurophysiological mechanisms and integrating them both into the total functioning complex of the individual.

A review of the available literature led the author to the following preliminary conclusions:

a) Malnutrition is a significant factor affecting the growth of children in all major preindustrial areas. When a child has been malnourished there is a persistant lag in growth which at each age level is reflected in short stature.

b) Not only somatic growth, as reflected in body length, weight and body

proportions, is affected by malnutrition. Its occurrence appears also to be associated with changes in psychological functioning, manifested in reduced intelligence test scores, developmental lags, and defective learning.

c) Animal experimentation provides support both for the stunting produced by nutritional lacks in early life, and for the effects of the deprivation on certain aspects of behavior.

d) Biochemical alterations induced by dietary inadequacies or by the interference with mechanisms for utilizing nutrients appear to result in arrest and regression of biochemical maturation in selected tissue and organs including the central nervous system.

e) The degree to which the individual's growth and development is affected by malnutrition varies with the severity of deprivation, the time of life at which this is experienced, its chronicity, and with the characteristics of the associated complications.

f) Speed of recovery from malnutrition depends not only on the introduction of adequate amounts and kinds of foods but also upon the environmental circumstances in which the recovery is taking place.

g) At the human level malnutrition is most persistently present in children whose familial environments are characterized by cultural as well as economic inadequacies. As a consequence, in attempting to assess the effects of nutritional lacks on both somatic growth and behavioral development, it is necessary either to control for or otherwise to assess the affects of these non-nutritional factors.

h) The manner in which the nervous system and its functioning are altered to result in reduced levels of intellectual competence is only partially suggested by psychological test studies and by conditional reflex changes. It is necessary to examine certain primary mechanisms underlying cognitive growth of a fuller view of the ways in which malnutrition affects intellect is to be obtained. Further, such an analysis is of potential significance for the development of

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methods for the more effective rehabilitation of malnourished children.

Two facts clearly emerge from the Cravioto study. For the rural children studied a difference in height is accompanied by a difference in intersensory integrative ability. For the upper social class urban sample, differences in height are not associated with differences in intersensory integrative competence. Therefore, height as such cannot be considered as a determinant of intersensory integrative organization unless such difference in height occurred under circumstances in which the height differential developed from causes which affect, intersensory integrative organization.

Differences in growth in the rural children are most likely to have derived from a failure to have received appropriate amounts and kinds of food (primary malnutrition), or to have been the product of infectious disease or parasitic infestations which have secondarily interfered with the individual's nutritional state either directly by increasing tissue catabolism without a compensatory increase in food intake, or indirectly through anorexia or social custom, in accordance with which, greatly reduced food consumption is deemed therapeutic in preschool children during illness and convalescence.

Clearly then, malnutrition could act in two ways--one deriving from a direct interference with the development of the central nervous system and the other from a series of indirect effects. In looking at the latter--three possible indirect effects are readily apparent:

1) Loss of learning time. Since the child was less responsive to his environment when malnourished, at the very least he had less time in which to learn and had lost a certain number of months of experience. On the simplest basis, therefore, he would be expected to show some developmental lag.

2) Interference with learning during critical periods of development. Learning is by no means simply a cumulative process. A considerable body of evidence exists which indicates that interference with the learning process at

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specific times during its course may result in distrubances in function that are both profound and of long term significance. Such distrubance is not merely a function of the length of time the organism is deprived of the opportunities for learning. Rather, what appears to be important is the correlation of the experimential opportunity with a given stage of development--the so-called critical periods of learning. Critical periods in human learning have not been definitively established, but in looking at the consequences associated with malnutrition at different ages one can derive some potentially useful hypothesis. Relevant to the relation between time of life at which malnutrition develops and learning may be the earlier report of Cravioto and Rables who have shown that as contrasted with older patients, infants under six months recovering from kwashiorkor did not recoup their mental age deficit during the recovery period. In older children, ranging from 15 to 41 months of age, too, the rate of recovery from the initial mental deficit varied in direct relation to chronological age at time of admission. Similarly, the findings of Barrera-Moncada in children, and those of Keys, et.al. in adults, indicates a strong association between persistence of later effects on mental performance and periods of onset and duration of malnutrition.

3) Mptovatopm amd ½erspma;otu cjamges. It should be recognized that the mother's response to the infant is to a considerable degree a function of the child's own characteristics of reactivity. One of the first effects of malnutrition is a reduction in the child's responsiveness to stimulation and the emergence of various degrees of apathy. Apathetic behavior in its turn can function to reduce the value of the child as a stimulus and to diminish the adult's responsiveness to him. Thus, apathy can provoke apathy and so contribute to a cumulative pattern of reduced adult-child interaction. If this occurs it can have consequence for stimulation, for learning, for maturation, and for interpersonal relations, the end result being significant backwardness in performance

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on later more complex learning tasks.

It is also possible to consider the effect of malnutrition upon the development of intersensory organization directly by modifying the growth and biochemical maturation of the brain. It should be remembered that increase in cell cytoplasm with extension of axons and dendrites, one of the processes associated with the growth of the human brain at birth, is largely a process of protein synthesis. From the microspoctro-graphic investigation of the regenerqting nerve fibers it has been estimated that protein substance increases more than 2,000 times as the apolar neuroblast matures into the young born cell. Perhaps an easier way to grasp the magnitude of this process way be simply to recall that at the time of birth the human brain is gaining weight at the rate of 1 to 2 mg per minute.

Changes in structure of the central nervous system due to feeding grossly inadequate diets to animals have been documented by Lowry and Platt. McCance, el. al. have shown gross alterations in the content of water and several electrolytes in the brain substance, and Flennor and associates have advanced evidence that interference with protein synthesis in the brain produces loss of disorders in mice. Ambrosius, et. al. have reported that severely malnourished children show a distortion of the normal relation between brain weight and total body weight. They have interpreted their finds as an indication of arrest growth of the central nervous system. It may well be that so-called critical periodicity in behavior represents the responsiveness of the nervous system when it is at a stage of biochemical organization. If this is the case nutritional inadequacy may interfere with both staging and timing of development of the brain and behavior. From this one might reasonably assume that failure for intersensory integration to occur at normal age-specific points can contribute to inadequate primary learning at the given age level.

Evidence already exists that the lag in the development of certain varieties of intersensory integrations have a high correlation with backwardness in learning

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to read. Thus, Birch and Belmont in their studies of reading disability in British children, and Kahn in her study of American school children, have shown that backwardness in reading is strongly associated with inadequacy in auditory-visual integration. Evidence is also available that indicates the dependence of visual-motor control in design-copying on visual-kinesthetic ingegrative adequacy. In a series of investigations of preschool and school children, Birch and Lefford have found skill in visual-kinesthetic integration to be highly and significantly correlated with design-copying in normal children. If it is recognized, with Baldwin, that such visual-motor control is essential for learning to write, the inadequacy in intersensory organization can interfere with a second primary educational skill-learning to write.

Thus, inadequacy of intersensory development can place the child at risk of failing to establish an ordinary normal background of conditionings in his preschool years and at the risk of failing to profit from educational experience in the school years.

The Cravioto study is probably the most significant report relative to preschool growth and development it has been my good fortune to read. This review, though lengthy and relatively complete, is not substitute for reading and rereading the document in full.

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Gulley, William and Lineberger, Robert. "Effect of Undernutrition on the Size and Composition of the Rat Brain." Journal of Nutrition, 96:1968, pgs. 375-381.

This study was designed to determine the effects of various periods of undernutrition on the growth and composition of the rat brain. Values for body weight, brain weight and total DNA, RNA, lipid and protein in the brains of rats on restricted feed consumption from 5 to 11, 17 and 60 days of age were significantly lower than the values for age-matched controls in each case. Also, the total cholesterol, phospholipid and cerebroside content of the brains of rats on restricted feeding until 60 days of age was lower than values obtained for brains of age-matched controls. Animals on restricted feed intake until at least 17 days of age did not recover any brain DNA or RNA when fed ad libitum until 110 days of age. Animals on restircted feed intake until 11, 17 or 60 days of age, did partially recover their deficit in brain weight and total brain protein and lipid, but these values were still significantly lower than normal. Also, the percentage of lipid in all of these brains remained significantly lower than normal. Similarly, the total amount and the percentage of phospholipid, cholesterol and cerebroside remained significantly lower than normal in the brains of rats undernourished until 60 days of age then fed ad libitum from 60 until 110 days of age. Of three major brain regions examined, restricted feeding affected the weight and DNA content of the cerebellum most severly.

These experiments control the implications of their study to "the effects of various period of undernutrition on the growth and composition of the rat brain". The reviewer finds a satisfying degree of responsibility inherent in the lack of extropolative inferences in their reporting.

The data produced here appears to agree with the preponderance of the reporting in this area. It is of particular interest in that it tends to lend

substance to the "critical period" thesis and definition. Such clarification, it seems, is the necessary starting point in our ultimate considerations relative to the more general effects of malnutrition.

Czajka, D. M. and Miller, S. A. "Protein Synthesis in Neonatal Rats Maintained Artifically on a Low Protein Diet."
Federation Proceedings 27:1968, pg. 727

"The rate of hepatic protein synthesis is lowest in the neonate and highest in the 11 day old rat pup (Czajka and Miller in preparation). As the first phase of a study of the effects of low protein diets during the preweaning period on the normal development pattern of protein synthesis neonatal rats were maintained on a low (0.6%) protein diet for two and four days. The diet was a dilution of rats milk prepared so that only the amount of protein was decreased. There were two groups of control rats in the experiment; one group was maintained by rat mothers and the other was fed whole rat's milk artificially according to the same schedule as the experimental animals. At two and four days rat pups were infected with 14-C-leucine and sacrificed from 30 minutes to 24 hours later. Liver and carcass were homogenized and a homogenates were centrifuged and two additional samples were obtained, microsomes and supernatant. The two control groups had similar rates of incorporation. When the pups were maintained on the low protein diet the rate of incorporation was similar to the control values in the carcass at two days and the liver at four days. (Supported in part by USPHS NIH grant 5-R01-HR-01346-03."

Davison, A. N. and Dobbing, J. "Myelination as a Vulnerable Period in Brain Development." British Medical Bulletin. Vol 22 (1) pgs. 40-44. 1966.

Histological examination has demonstrated that development of the brain occurs in several successive stages. Thus cellular proliferation is followed by growth of cells, axons and dendrites and later still by myelination.

There is now good evidence (due to considerable advances in our knowledge relative to biochemical processes and chemical construction) to suggest that biological membranes are triple-layered membrane structures made up of an inner lipid layer sandwiched between two outer protein layers (Robertson, 1959). X-Ray diffraction and electron-microscopic studies show that the myelin sheath is composed of numerous lamellar wrapped about the axon, each lamella consisting of two unit membranes derived from the plasma membrane of the parent oligodendroglial cell.

Myelination occurs at different times in various areas of the nervous systems and its time of onset varies for each species. The process is preceded by a proliferqtion of oligodendrocytes (Bensted, Dobbing, Morgan, Reid, Payling and Wright, 1957) and by the accumulation of hydrophobic lipid droplets in the neuropil, firstly in the spinal cord and later in the brain. Recent work on the accretion of myelin lipids during development shows that, after an early period of rapid growth, this process continues for a long period; for example, the human brain increases rapidly during the first several years of life, then tapers off but does not stop growth in wigght until adolescence. Since much of the increase in wet weight of the brain during the later phase of development is due to deposition of myelin, it is possible to attempt a qualitative comparison of the process in different species.

Although histochemical and chemical methods may indicate the onset, localization, rate and extent of myelination, they provide no information on the turn-

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over of its components. Waelsch, Sperry and Stoyanoff (1940) and Bloch, Berg and Rittenberg (1943) first suggested that adult brain cholesterol, unlike that of other organs, was metabolically stable. There was little incorporation of deuterium from ingested heavy water and deuterium-labelled cholesterol in the adult brain, even though there was rapid uptake into the brain lipids of newborn rats. The apparent metabolic stability of myelin constituents, once laid down, makes possible the use of analytical procedures to measure brain growth. Consequently in the mature brain, for example, once myelination is complete, it is unlikely that stress such as undernutrition will appreciably reduce the amount of myelin, and this could explain some of the findings which have led to the belief that undernutrition "spares" the adult brain.

It therefore seems reasonable to propose that undernutrition (and any other stress) will vary in its effect on myelin according to its timing in relation to the process of myelination. It is also possible that the characteristics and extent of the "catch up", on the return of favorable circumstances, will depend similarly on the timing of the stress; and even if metabolic derangement be corrected, it may be possible to compensate subsequently for developmental abnormality (see Eayrs and Levine, 1963). The hypothesis may also be extended to other metabbbically stable brain constituents such as DNA and hence to cellularity.

In reviewing the experimental evidence for these proposals, the species differences in the timing of the period of maximum rate of myelination relative to birth are of vital importance. This is particularly true for the xtrapolation of findings from one species to another, which may well be otherwise quite valid, because of the species similarity of chemical composition and metabolic behavior. Tentative extrapolation to man would place the human infant's vulnerable period from about the seventh month (intra-uterine) to the first few months

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of postnatal life. The full-term newborn, and even more so the prematurely born infant, would thus be at special risk from external factors in this respect as in so many others (see Wigglesworth, 1966).

The question arises as to whether or not animal experiments are relevant to the human species. Most of the animal nutritional experiments have involved a degree of undernutrition much more severe than any likely to occur in the normal human being. Nevertheless, it may be (see, e.g. Dobbing, 1964) that quite minor deprivations applied during the vulnerable period can produce significant changes. Thus it is possible that low birth-weight without chronological prematurity, or the relatively low birth-weight of full term infants in underdeveloped countries (Brown, 1966; Wigglesworth, 1966), are examples of the application of comparatively small restrictions during intra-uterine life at a vulnerable period for the human foetal brain. The prematurely born infant's brain, however, may be much more susceptible to deprivation, because it would normally be protected to a great extent in utero at this vulnerable period of development.

Of most concern is whether comparatively minor early stress can produce permanent changes resulting in intellectual or emotional impairment; and secondly, whether, if whole body growth is controlled by factors in the brain affected at this time, human body size can be permanently reduced as it can in animals. There is little real evidence in man for either proposition, but this may be simply because it would be difficult to collect. Factors affecting eventual "intelligence" as well as body-size are multiple and interacting, and many of the better-known ones (such as social status) may mainly operate, if at all, later than the period of maximum brain growth. Nevertheless there does seem to be ultimate psychological impairment in infants of low brain-weight (Harper and Wiener, 1965). Early infantile undernutrition may also act similarly (Stoch and Smythe, 1963) and

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it has recently been suggested that the recovery of intellectual performance reduced by undernutrition may be possible in babies whose severe degree of kwashiorkor occurred after six months of age. If they are malnourished earlier, the intellectual damage may be permanent (Cravioto and Robles, 1965). The incidence of permanent brain damage associated with idiopathic spontaneous hypoglycemia is also much greater in infants presenting before six months of age, (Haworth and Coodin, 1960). The impaired intellectual development of phenylketonuria is associated with defective myelination (Crome, Tymms and Woolf, 1962; Waisman, Hable, Wang and Akert, 1964), although a causal relationship remains to be demonstrated. Unfortunately the scanty information available about physical effects on the brain relates only to fresh brain wet weight, and sometimes only to head circumference, both of which have been shown to be unreliable guides to brain composition in experimental animal undernutrition.

Whether the slower rate of development exhibited throughout childhood in children with late adolescense and smaller body size (Tanner, 1961) could be the result of similar early deprivation is again purely speculative but, the smaller the stress required to produce such an effect during the vulnerable period, the more reasonable this explanation becomes. There certainly seems to be some correlation between small stature and intellectual performance in children (Scott, 1962) and in adults (Schreider, 1965; Scott, Illsey and Thomson, 1956).

The Davison and Dobbing paper impresses as being adequately thorough in its' consideration of myelination and the consequent relative significance to total brain development. The review of available literature incorporated in the paper, suggests reasonable completeness and mutually supportive reciprocity.

It is most unfortunate that this article and a closely correlated paper re-

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ported by Benton and others, 1966, were published simultaneously. The two articles differ quite markedly and significantly in their analysis of the ultimate effects of encumbered myelination during the "critical period" of its growth. It would have been most valuable to have available comparative comments from at least one of these expert sources.

The reviewer suspects that such commentary may have well considered a modification of the "critical period" definition or a critique of the modes used in the histological and biochemical evaluations.

The differences, that are reported, culminating from the disturbance of this growth period in brain development must elicit some response.

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Dayton, Delbert H. "Early Malnutrition and Human Development" Children. Vol. 16: p. 210-217, Dec. 1969.

More studies are needed to definitively assess the relationship between malnutrition and mental development.

One promising study is occurring in Guatemala where groups of matched children are to be watched from birth to 7 years of age. One group will live on the customary diet, the other is being provided a nutritious supplement.

The preliminary data of two nutrition surveys supported by the Department of Health, Education and Welfare and Public Health Service, indicate that malnutrition among certain groups of children also exists in the United States. Though the problem differs in cause and degree from that in developing countries, the basic questions of the relationship of mental development and malnutrition are the same.

More information is needed regarding maternal nutrition and its effects since it is known to be associated with increased rates of morbidity during pregnancy and of premature delivery. Evidence is increasing that the nutritional experiences of the potential mother before conception may also be extremely important to subsequent intrauterine growth.

Some studies have shown that breast-fed infants in developing countries have patterns of growth similar to well-nourished infants in North America during the first six months of life. After this point, breast milk alone may not be sufficient to sustain them or the child may be weaned and the child's growth begins to diverge from the North American standards. Children in certain poverty groups in the United States seem to have the same nutritional problems at the age of weaning as children in developing countries.

The classic severe protein malnutrition (kwashiorker) often becomes evident around the age of two.

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Mental Development

Studies of animals have indicated that growth in all organs occurs in three phases: 1. hyperplasia, during which the number of cells increases; 2. hyperplasis and hypertophy, during which the number of cells continues to increase and the size of the individual cells also increases; and 3. hypertophy, where growth occurs only by increase in cell size.

These studies suggest that during the phase of hyperplasia, malnutrition can interfere with cell division, resulting in fewer cells in the brain; which seems to have a permanent effect, whereas malnutrition during hypertophy results in smaller than normal cell size, which can be corrected by providing adequate nutrition.

In humans, the brain grows most during the fetal period and by the end of the first year has assumed 70% of its adult weight and by the end of two years is nearly complete in growth.

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Validation Needed

Past studies have shown significant differences on mental tests between malnourished children and better nourished children in the control groups.

For example, Stoch and Smythe, in South Africa, compared marasmic children to a matched control group over an 11 year span and found the experimental group to show significantly lower results than the control group on physical measurements (height, weight, and head circumference) and one various intelligence tests. Differences were especially significant in visual-motor ability and pattern perception. Although environmental and other causes are suspected to contribute to the results, the smaller head circumferences suggests that a stunting of the brain growth may have resulted from malnutrition.

Klein, in Guatemala demonstrated differences using a battery of psychological tests in terms of short-term memory, between a rehabilitated group of severely

malnutritioned children and a similar group who had never manifested overt signs of severe malnutrition.

Cravioto, in a later Guatemalan study, correlated stature with neuro-integrative function and found those with lowest stature produced the greater number of errors on intersensory testing. However other than malnutrition may be a factor.

More studies of mental development and its malnutrition as measured by psychologic tests are needed. At present, most studies have been cross-sectional with little from longetudinal studies which follow the same children over an extended period of time which are needed to prove a cause and effect relationship between nutrition and mental development. Other factors can affect a child's mental functioning and need to be differentiated from the effects of malnutrion as well.

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Nutritional Assessment:

Growth retardation and various clinical syndromes resulting from malnutrition in animals and man have been in the professional literature for many years. Cicily Williams in 1931, first described kwashiorker while in Africa on the Gold Coast, the main cause of which is an extremely inadequate intake of protein foods. She described the main clinical features which if unchecked lead to marasmus and eventual death, but also produced cures by feeding milk to children suffering from it, thereby showing that this was a disease of malutrition.

Surveys to determine the prevalence of protein-calorie malnutrition suggest that perhaps two thirds of the children in developing areas of the world are not getting enough to eat. Although only 5 to 10% of these children exhibit kwashiorder, it would not be unrealistic to state that at least 50 to 75% of the children in the developing countries have a degree of malnutrition that has

caused physical growth failure as evaluated by height and weight data and assessment of bone development. Nutritional problems in the United States, though less extensive, do exist.

An assessment of the nutritional status of a population, including edentification of deficiencies, is essential for sound social and economic planning.

In studies of bone maturation, radiographs have shown significant differences between wel nourished populations and poorly nourished populations.

Also more sensitive biochemical determining tests are needed for the evaluation of individual nutritional status. Early, less severe malnutrition is presently difficult to detect.

The effect of infectious disease on the malnutritioned child is an important consideration. The synergism between nutrition and infection complicates any prediction regarding the development of the child caught in a complex net of nutritional deficits, poor hygienic conditions, inadequate medical care and sociocultural patterns that tend to perpetuate such problems.

Some Solutions:

The obvious solution, providing food, is an oversimplified solution to a complex problem. Surpluses of food around the world are dwindling and the high transportation costs and losses due to spoilage, rodents and pests are a problem. Supplying foods can be only a temporary solution. Ultimately it must be produced in the areas where needed. This doesn't solve the problem in prosperous countries. Nutrition education, along with a nutritious, inexpensive food supplement acceptable to the people in need is most important.

The author offers information not frequently mentioned. The three phases of growth in organs is one. Also the studies of bone growth comparisons are not

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widely discussed. As to the author's conclusions, in theory it is reasonable to suggest local growing of crops, but it is obvious that innumerable children will suffer the effects of malnutrion before this occurs.

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Dickerson, J.W.T. and Walmsley, Ann. "The Effect of Undernutrition and Subsequent Rehabilitation on the Growth and Composition of the Central Nervous System of the Rat." Brain Research, Vol. 90, pgs. 897-906, (1967)

Weanling rats were undernourished until they were 11 weeks old. Some of them were then allowed unlimited access to food for one, two or eight weeks. The effect of undernutrition and subsequent rehabilitation on the brain, and on the weight and "thickness" of the spinal cord was studied. The brain and the cord were analysed for water, total nitrogen, total phosphorus, DNA-P and cholesterol.

The weight of the brain of the undernourished rats was appropriate for their body weight, but the cord was heavier than normal due to its greater thickness. There was a positive correlation between the weight of the brain and the length of the skull.

There was no significant difference between either the concentration, or the absolute amount of DNA-P in the brains of the experimental animals and their controls. The concentration of cholesterol in the brains of the undernourished animals was higher than in normal brains of the same weight, and slightly higher in those of the same age.

In the spinal cord undernutrition prevented the normal fall in the concentration of DNA-P. The concentration of cholesterol in the cord increased during undernutrition and was not significantly different from that in normal cords of the same age.

The effect of undernutrition of the severity imposed on weanling rats were transient, and in some cases were corrected by rehabilitation for two weeks.

The results of this study and those of Dabbing and Weddowson (1965) suggest that whenever growth of the brain is retarded without seriously affecting its composition and its proper relationship to body weight, full rehabilitation will be possible. When, however, undernutrition begins before the brain has reached

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its mature composition, the concentration of its constituents are appropriate to a younger animal, and, as with the pigs (Dickerson et al., 1967) rehabilitation may not be complete. The factors which determine these parameters appear to be the timing as well as the duration and severity of the undernutrition.

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Eichenwald, Heinz and Fry, Peggy Crooke. "Nutriton and Learning" Science. Vol. 163: p. 644-648, February 1969.

For some time, it has been scientifically accpptable to ascribe many behavioral characteristics to conditioning. Research is recently indicating, however, that it may rather be biochemical conditioning. The author suggests that malnutrition not only affects physical growth but may produce irreversible mental and emotional changes.

Various studies using animals have shown that inadequate nutrition (calories and protein) coinciding with the period in life in which the brain is growing most rapidly, produces a brain not only smaller at maturity than in control animals but also one which matures biochemically and functionally at a slower rate. Studies do not indicate, however, if the function of the brain is permanently altered with short term simple undernutrition of the weaning period. The timing and duration of malnutrition during infancy is probably critical in determining whether anatomic and biochemical damage can be subsequently healed. The results of one study appeared to show that restruction of calories may slow the rate of cell multiplication (maturation) whereas later restriction affects only cell size (growth.) Data also suggests that inadequate protein nutrition or synthesis or both, during brain development result in changes in function and that, if the degree of deprivation were sufficiently severe and prolonged, the changes in function might be permanent.

So in animals, the simple calorie deprevation during the nursind period apparently results in behavioral changes but doesn't seem to affect its problem solving ability. Protein deprevation causes behavioral changes and also reduces the capacity of the experimental animal to learn at an early age - as is the case with those with malnourished mothers.

The author also discusses the relationship between nutrition, growth, infection and the environment and suggests in the more cmmplex case of humans,

these environmental factors undoubtedly contribute significantly to the effects of malnutrition on behavior and function. The intellectual attainments of children who have recovered from a clinically severe episode of protein-calorie malnutrition are consistantly lower than those of individaals with adequate nutrition during infancy.

He goes on to reiterate the need for further research and means for implementing effective plans.

One point the author makes worth noting, is the difference between simple calorie deprivation and protein calorie deprivation. In the United States, one might assume that protein calorie deprevation would be the most prevelant of the two and according to the author, the most critical.

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Frisch, R. E. "Present Status of the Supposition that Malnutrition Causes Permanent Mental Retardation" Amer. J. Clin. Nutr. Vol. 23, p. 189-195, February, 1970.

The author suggests that much of the literature published supporting the supposition that malnutrition causes permanent retardation is not based on conclusive scientific evidence - and is indeed the purpose of this article. The author will discuss only direct evidence -actual tests of mental and motor abilities of malnourished children.

Experiments with animals and resulting conclusions may not relate to humans because the period of critical brain growth for humans is the last few weeks of intrauterine life and the first few months following birth - quite different from animals.

Kwashiorker (acute protein-calorie malnutrition) is discussed in the light of three studies. The conclusions seem to show that children above 15 months of age are not permanently retarded by extreme malnutrition; the evidence is inconclusive for children below six months and nothing is known about children between six and fifteen months of age.

The difference in reversibility of the effect of malnutrition seems to be the age at which the child is affected. In less developed countries the babies seem to be protected since they are nursed to six months of age. Recent early weaning trends in Latin America appear to be causing non-reversible effects in mental development due to inadequate quality, high starch, low nutrition foods and hygiene. It appears that the greatest risk of irreversible brain damage occurs with children who suffer deprevation before birth (considering the critical period of brain growth is in its peak near birth). Such children include those who suffered from placental restriction at this time and are found in all societies.

The next aspect of the mental development problem concerns chronically

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malnourished children. Such children test lower than normal but are not mentally apathetic to stimuli in their environment as are those with kwashiorker. The main problem here becomes the basis of the test results. Is it due to poor brain growth or damage, reversible or irreversible, due to malnutrition or cultural environment?

The author questions the validity of the conclusions of Stoch and Smythe and others who maintain that the smaller head circumferance found in children experiencing severe malnutrition the first two years of life shows the irrevocable reduction in brain size and resulting restriction of intellectual development as shown by smaller than normal head circumference. Robinow and Garn suggest that in such children, she skull is thinner than normal. In addition, others show that children with reduced head circumference in fac¢ have brains of normal weight. Normally there is no correlation between head circumference and intellegence. The inferior performance of such children must be due to either cultural deprevation or brain damage (reversible or irreversible) concludes the author.

Monckeburg, who studied malnutritioned children in Chili, in using the Iowa Reference Standard and in being uncertain of the quality of follow-through upon which the study depended, made an unwarrented conclusion when he stated that brain damage in infancy is permanent at least up to the sixth year of life, despite improving nutritional conditions.

After mentioning some inconclusive studies, the author gives a reseme of Skeel's study using mother surrogates with an experimental group of 13 in an orphanage where it was found that the experimental group gained an average of 2815 I.Q. points (11 of the former maintained and increased their earlier gains in I.Q. after being placed in adoptive homes. The two who were kept in the orphanage declined in mental growth.)

The author concludes by stating that "long-term studies which attempt to

differentiate between the effects of environment on mental growth and possible effects of malnourishment on the central nervous system in children are now in progress..." Until conclusive evidence is available, however, "surmises should not be treated as facts and millions of malnourished children should not be condemened as permanently retarded, mentally."

The evidence available in the area of malnutrition and its effect upon mental development is so varied that one can compile studies that support his preconception on the topic. Still, the more important point is that we cannot continue to allow malnutrition to be a way of life in many parts of the world and certainly we have little excuse for it occurring in the United States. Since there are studies that show malnutrition to be a contributing factor and since it is physically uncomfortable to be hungry, why be concerned so greatly about providing the pure research so many are claiming we need before we can act? Regardless of its revocability or irrivocability, we should be making a concerted effort to eliminate hunger.

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Glaser, Helen, Heagarty, Margaret, Bullard, Dexter and Pivchik, Elizabeth. "Physical and Psychological Development of Children with Early Failure to Thrive" Journal of Pediatrics. Vol. 73, p. 690-708, November, 1968.

This study examined fifty children who were hospitalized with the failure to thrive syndrome which includes a broad spectrum of disorders which emcompasses difficult diagnostic problems requiring discrimination between subtle organic diseases and complex social and emotional disorders.

Failure to grow in size, to gain weight, or to develop motor skills were bheemajor complaints presented by the parents of the fifty patients who came from all social strata. The children were pale, malnourished, showed loss of subcutaneous tissue and muscle mass, were below normal in height and weight. The infants were lethargic and apathelic. (The age range being fifteen under 6 months, thirteen from 7 to 12 years, ten form 13 to 18 and twelve over 18 years old. Upon discharge, they were returned to the care of their private physicians.

A follow-up study revealed a substantial incidence of continued growth deficits, both in height and weight. Mental retardation, emotional disturbance, and family dysfunction were commonly found, although a minority of the children from adequate home environments appeared to have recovered spontaneously without detectable sequelae.

The age span of the children and sparse information given about them, make it difficult to comment about the study. It would be benefical to note similarities within the group that recovered spontaneously among other things.

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Graham, George. "Effect of Infantile Malnutrition on Growth" Federation Proceedings. Vol. 26, January-June, 1967.

"In this article Mr. Graham reports data associated with the observation of fifty-three severely malnourished infants and children followed for an average of 34 months after hospital admission and under a variety of circumstances. He reports that although the prognosis for growth can be improved by optimum diet, severe deficits seemingly cannot be made up, particularly the deficit in head size. Although radiological bone age parallels heights age and suggests that the duration of linear growth will be prolonged, comparison with the growth of a much larger undernourished population suggests that this will not be the case and that most of the children will be permanently stunted."

Mr. Graham's paper, although reasonably informative in terms of growth charts, only by inference relates itself to the more consequent issue of general social implication. Possibly a different greater latitude in comparable analysis and correlates would reveal more in this area.

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Granoff, Dan; Howard, Evelyn. "Malnutrition in Infancy and Brain Development." The Journal of Pediatrics, Vol. 75, No. 4, October 1964, pgs. 732-733.

Data collected in 1965 indicated that brain growth and cerebral DNA are significantly reduced by food restriction or other stress between 2 and 7 days of age (in rats), and these changes are not fully reversible even after prolonged realimentation. Winick (1969) failed to observe a reduction in cerebral DNA at 8 days of age. The difference may be procedural: Granoff enforced food restriction by removing the young to an incubator for 16 hours per day, while Winick set up large and small nursing groups. It is suggested that a lactating female rat may be able to supply more nearly adequate nutrition for a group of 18 up to 10 days of age, but that later when demands are maximal the relative restriction increases.

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In the normal mouse, between 2 and 14 days of age, cerebral and cerebellar DNA increases 25 and 580 per cent respectively. Food restrictions between 2 and 16 days of age result in permanent reductions in brain size and DNA in adult mice.

The importance of regional DNA determinations rather than analysis of whole brain was also evident in a recent study of DNA increase during development of the human fetus (Howard, Granoff and Bujnovszky, 1969). Cerebellar DNA was found to increase exponentially as late as 30 weeks' gestation in the human. In contrast, the rate of increase in cerebral DNA had begun to decline by the fourteenth week.

The deficit in the cholesterol, per milligram of tissue, in the cerebrum of adult mice that underwent food restriction in infancy is rather small, on the order of 3 or 4 percent (Howard and Granoff, 1968). This reduction in cerebral cholesterol might reflect a reduction in either myelin or total cell surface area associated with a selective suppression of certain neuron types,

and not necessarily an irreversible interference with myelin-synthesizing cells.

The functional significance of these alterations in brain composition needs further clarification. Animal learning is presumably subject to complex influences and are not always amenable to the extrapolative presumption so readily found in the literature.

This article was primarily a response to the Winick paper presented in the May 1969 issue of this journal. It appears in the form of an addenda and, as such, supplements the previous paper in some rather significant ways. Of particular interest were comments relative to the complexity of measuring animal learning in a meaningful way and those relating to the minimal reduction of cerebral cholesterol in adult mice (after malnutrition). This later bit of evidence influences the arguments perceived between the Davison (1966) and Benton (1966) articles included in this review.

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Gyorgy, Paul. "Protein-calorie and Vitamin A Malnutrition in Southeast Asia". Federation Proceedings, Vol. 27, No. 3, pgs. 949-953, May-June, 1968.

The gap between the affluent few and the hungry millions is widening and may become unbridgeable if properly directed efforts fail. The hungry people need food, improved living standards, and the hope for a better life, if not for themselves, at least for their children and succeeding generations.

In many parts of the world, especially in the rice-eating countries of Southeast Asia, up to 70-80% of the preschool children are undernourished and have no opportunity to develope their full potential. With rice as the staple food of the population, the growing child receives insufficient amounts of protein. Even the caloric requirement is not covered since the young child is unable to eat adequate amounts of bulky boiled rice. In countries like Indonesia and also Thailand, especially in the northeast provinces, the diet is also poor in vitamin A.

These Indonesian studies found a very significant growth retardation amounting, in comparison to the American normal values, to 5 months for a 9-month-old infant and to 4 years for a 12-year-old Indonesian child. This phenomenon, call by Ramos-Galvan (1966) "rheostosis", is an impressive manifestation of metabolic adaption, the nature of which has not yet been elucidated. As recent anthropological studies from Japan clearly indicate, this adaptive retardation in length-growth is due not so much to genetic as to environmental factors, especially nutrition.

In this study a statistically significant positive correlation was found between weight and height measured in 1963-1964 with the original classification in 1957-1959 in groups (a) acceptable and (b) malnourished, and especially marked in (c) the group malnourished with vitamin A deficiency. It is of interest that the serum vitamin A levels were significantly higher in the mothers of the sample is compared with all children (45 mothers and 110 children comprised sample). A

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significantly lower I.Q. was found in 1964 in children who in 1957-1959 had shown malnutrition combined with Vitamin A deficiency. Using the electro-retinogram as a response criterion, eye disease was also found to correlate highly with the blood serum vitamin A levels.

In extensive studies in Thailand on bladder stone disease, observations were mad which appear to link the epidemiology of the disease with low-protein intake, as one of probably several etiologic factors. As circumstantial evidence for this assumption may be mentioned: 1) higher incidence of the disease in rural, compared with urban areas; 2) dietary habits in the village, such as early supplement of rice and bananas to young, even to newborn infants; and 3) low sulfate and phosphate excretions in the urine.

Improvement in nutritional conditions, in anology to infectious diseases, should center preferably on preventions and not on therapy. Permanent damage if caused by early malnutrition can be eliminated only by timely preventive action.

These studies further, appear to substantiate that "self-help" and "conditioning" of the village people to use proper food more or less as "medicine" is possible. "Hand outs" will not guarantee success and are often resented by the people. Maternal and child care centers, as important as they are, will not replace the "attache" at the grass roots level--in the homes of villages. Thus, it is no surprise that all the well-meaning efforts of the governments, as well as foundations, religions and private organizations were in the past 20 years largely unsuccessful with regard to improvement of nutrition and general rural rehabilitation.

Experience in highly developed countries has shown that improvement of the standard of living leads to reduction in family size. Today, better living standards and family planning must go hand in hand, the situation is so urgent.

Dr. Gyorgy and his associates have, with Cavioto and Wyniche, accomplished

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a significant penetration into the dark area of actual nutritional studies on humans. Direct results from these efforts are infanitely more meaningful than extropolations from other animal data.

Even more than the others, Dr. Gyorgy has some taste for how remedial procedures may be conditioned within particular populations. Thats where it's all at.

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Howard, Evelyn and Granoff, Dan. "Effect of Neonatal Food Restriction in Mice and Brain Growth, DNA and Cholesterol, and on Adult Delayed Response Learning," Journal of Nutrition, Vol. 95: pgs. 11-121, 1968.

This tudy was designed to examine the long-term effects of a limited period of nutritional restriction on ultimate brain size and functional capacity. Experimental mice were intermittently removed from their mothers during the period of rapid brain growth between 2 and 16 days of age, producing a 57% reduction in body weight compared with littermate controls. Thereafter they were fed adlibitum. At 9 months, body, cerebral and cerebellar weights were reduced in the males by 17, 7 and 14%, respectfvely, below control values. Total DNA was reduced 8% in the cerebrum and 22% in the cerebellum. Cerebral cholesterol was reduced slightly. Despite these brain changes, the restricted group showed no lasting impairment in volentary running, in learning a Lashely type III maze, or a visual discrimination with escape from water as a reward, the restricted males showed an unexpected improvement in learning a delayed response task. The restriction experience may have altered reasction patterns so that the restricted males were able to more than compensate for any possible handicap due to the nutritional deprivation. The restricted females did not manifest this improved performance, and their final body size reduction exceeded that of the males.

In light of the authors' stated purpose, "to examine the long-term effects of a limited period of nutritional restriction on ultimate brain size and function", this study is of significance if only in terms of the dangers of extropolating data prematurely and in too general a manner. Certainly there is general concern relative to the effects of malnutrition upon the ultimate human function. And often this concern has led to extropolations which are questionable in terms of the emperical evidence available. This tudy demonstrates the dangers of this without thorough consideration of the many variables involved.

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Leland, Henry. "The Relationship Between Intelligence and Mental Retardation". American Journal of Mental Deficiency, Vol. 73, 1969, ppgs. 533-535.

An appropriate classification system must take into consideration both "bookkeeping" and diagnostic needs. Such a system must serve the person being classified. It must be relevant to the treatment, training, or rehabilitation needs of the specific individual. It is not to our advantage to dichotomize mentally retarded groups based on presumed etiologies. Most of the mentally retarded with whom we hope knowing contact are so labeled because of maladoption and behavioral difficulties. The only serviceable classification system is one which groups individuals by their ability to cope with specific critical demands and which provides a guide to the modification and reversal of these behaviors.

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No doubt Dr. Leland has made a viable point in this article. Change in this direction has taken place and will continue. The slowness of this progress however is thought, possibly, to be the result of convections the presently, such change, is simply to the less arbituary. No ultimate--all answering--beomedical diagnostic labeling is within sight.

Osofsky, Howard [illegible]. "Antenatal Malnutrition: Its Relationship to Subsequent Infant and Chil[illegible]velopment." American J. Obstet. Gynec. Vol. 105, p. 1150-9, Dec. 69.

The basis for this review rests upon the hypothesis that malnutrition prior to birth relates to subsequent and specific developmental problems. Much of the data available is of an indirect nature. Most of the clinical, neurological, and developmental data deals with children and have a primary pediatric focus rather than obstetric data. However, much has inferential importance for this area.

Experimental animal studies:

Animal studies such as by Jackson and Stewart, Widdowson, Dickerson, and McCance, Davison and Dobbing, Dickerson, Dobbing and McCance, have demonstrated that maturational development, including brain development, can be adversely affected by finite periods of undernutrition at different ages in the maturation of animals. The earlier the nutritional deprevation, the more profound and irreversible were the changes studied. Dickerson and Dobbing postulate that the effects upon the brain would have been even greater if the undernutrition were begun during pregnancy.

Platt and co-workers, in London, found that extending the malnutrition to encompass pregnancy has resulted in clear signs of neurological involvement among dogs. Athetoid movements of the head and neck, ataxic gait and epileptiform convulsions have been observed. Electroencephalograms have demonstrated an access of irregular, slow activity of large amplitude and multifocal spikes and sharp waves, particularly during sleep. (This has not been noted in pups born of well nourished mothers.) While the clinical changes seem to be reversible, gliasis and central nervous system cellular damage have not appeard to be completely reversible.

Cowley and Grisel in South Africa attempted to carefully study the effects of a low protein diet prior to and following birth upon successive generations

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of white rats. Retardation of growth was observed and mortality rates were high. Though no differences were observed in exploratory behavior, there was marked difference in intelligence between the offspring of the experimental and control groups. The low protein rates scored lower on the problems of the Hebb-Williams test and took longer to reach the goal box. In the follow-up study, the first filial generation low protein rats were mated at 120 days of age with normal male laboratory rats. Their offspring were continued on low protein diets and were studied as a second filial generation of low protein animals. The low protein second generation pups demonstrated marked abnormalities as compared to the other two groups. Less normal head and limb movement, less coordinated exploratory behavior, slower maturational development, a greater lag in age reaction to sound stimulation and less intellegence were all noted. This suggests cumulative effects over the two generations.

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Human studies:

Information here is less precise due to the complexity of interrelated issues which tend to confound human data. Biologic, environmental and secondary factors may be associated with conditions of malnutrition.

Except in time of war with deliberate starvation created by aggressors, pure malnutrition is hard to isolate. Usually, malnutrition among humans is borderline in degree and data may be difficult to interpret.

Methods of developmental assessment and psychologic techniques have been crude and often not predictive. Further investigation is needed here.

The most retevant data of a detailed nature related to reflexes came from Russian laboratories in the study of children. It was demonstrated that malnutrition leads to changes in conditioned reflexes which begin before the clinical and electroencephalographic evidence that function of the brain in children is affected by states of malnutrition and may persist following correction of

the nutritional deficit (Nelson, Engel) Antenatal and perinatal data would provide valuable additional information.

Human studies have also demonstrated neurological deficits specific to particular types of deficiency such as vitamin B6 (deficiency associated with mental retardation), vitamin A (Genest, Sarwano, and Gyorgy) (deficiency caused irreversible changes in the retina).

As to studies dealing with pregnancy, Smith, Baird and Eastman and Jackson have all reported infants of smaller size than expected, as an accomponiment of maternal undernutrition or lack of weight gain, during pregnancy.

A study be Kugelmass, Poull, and Samuel observed the effects of nutritional improvement among 91 hospitalized malnourished children in New York City. Their average I.Q. for the retarded experimental children increased 10 points, and 18 points for the not retarded experimental children, in contrast to no I.Q. change in the control group. The study is significant in noting the reversibility of effects at the ages studied.

Monkeberg's three to six year follow-up on 14 children with severe marasmic malnutrition during infancy, suggests more severe - and possibly irreversible changes - with deprivation at an earlier time.

Stoch and Smythe, in a series of two reports have followed 20 malnourished infants in South Africa for 11 years. Throughout the study the I.Q.'s of the malnourished children averaged 20 points lower than the control groups. The pattern that emerged in the malnourished group resembled that of some brain - damaged children, with a defect of visular motor ability and pattern perception. Although the control group didn't closely match the experimental group in environment, it is likely that malnutrition among the parents of the experimental group before, and during pregnancy is most likely.

In the study of Cravioto, previous research had indicated that differences in growth in a village in Guatemala, were a significant indicator of malnutrition.

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Having controled genetic factors, intersensory integration was compared between the shorter and taller children. The only strong positive association between background circumstances and height was between the height of the child and the education level of the mother. (the lower the education level, the greater the likelihood that the child would be short) Poor maternal education may be expected to be correlated with poor nutrition during pregnancy and early infancy.

Conclusions and implications:

Animal data clearly indicate that malnutrition affects both physiologic and psychological development. The type of aberation qualitatively differs dependant upon the specific nutrient which is deprived. The timing, severity, and duration of malnutrition further markedly influence the quality, extent, and degree of reversibility of observed deficits. Persistance of malnutrition across generations appears to worsen outcome and prognosis.

Human data are more difficult to interpret. Rarely does the extent of deprivation come close to equalling that used in animal experiments and usually involves more generalized deprivation such as poverty, lack of education, incidence of infection and disease.

Also, studies are often too broad and poorly controled. There has been little work done concerning brain development before and shortly after birth.

The author makes several points to consider. First, there is indeed a lack of research, at least in the last five years, in the area of prenatal and maternal malnutrition and its relationship to the development of the brain. Most studies in the area of malnutrition and mental development suggest that there is no adverse effect until weaning. Yet the author cited one study in particular which showed such a possible effect with rats. Also, a good point is made in regard to the poor education of mothers affecting the nutrition of

their children. There is the opportunity to rectify this problem with the widespread introduction of day care centers which will accept children from birth, as well as more maternal health centers.

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Pollitt,KBrnesto, PhD. "Ecology, Malnutrition, and Mental Development" Psychosom. Med. Vol. 31, p. 193-200, May-June 1969.

The author suggests that the conclusions of studies on the affect of nutrition on learning ability are not warranted. This ppapur will attempt to point out that behavioral studies attempting to assess the specific effect of nutrition deficiency on learning ability have not considered the coexisting biological and social factors which interact with malnutrition and which may codetermine the poor test performance. Also, this paper will show that the relationship between malnutrition and poor test performance may be the sole result of method of the study.

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Critical Review:

Human studies of severe protein calorie malnutrition have shown that children of the same geographic location and socioeconomic status with malnutrition score lower in I.Q. than those without malnutrition - the result being due to the malnutrition. However this inference is weakened by two methodological problems: (1) It is difficult to find an appropriate measure of nutritional history in children. Stature, a popular measure, is inadequate because it is indicative of many other factors. Pollitt and Ricciuti found that, in comparison to tall subjects, short children were more likely to have shorter mothers with a higher number of pregnancies and less years of schooling, to have lower reported birth weight and to come from less stable homes. These differences were found to occur within a homogenous socioeconomic population. (2) It is difficult to separage the nutritional component from the complex of accompanying biological and social variables which affect the overall development of a malnourished child. In the studies of Graham and Morales and Stoch and Smythe, the experimental groups were also living in extreme detrimental home and family conditons.

There is also data suggesting the existance of more specific biological

and social variables associated with malnutrition, especially with nutritional marasmus. In addition to the studies of high kwashiorker and marasmus incidence in third or later born children (Graham and Morales) and short time span between pregnancies (McLaren), some show an association between frequent episodes of infectious diarrhea and malnutrition and others show such an association with abrupt mother-child separation.

Also in low socio-economic groups there is evidence that a high number of pregnancies are associated with lower birth weight, higher incidence of prematurity, congenital malormations of the nervous system and high incidence of neonatal mortality.

The psychological significance of these factors associated with malnutrition is that they are influences on behavioral development prior to, during and after the presence of malnutrition. Low maternal education might determine inadequate child caring practices, inappropriate food habits, and other forms of maternal behavior that might be detrimental to the child's intellectual growth. A lot of evidence suggests a positive relationship between maternal education and the child's level of intellectual development.

Then too, the gradual deterioration, accompanied by apathy and listelessness, and resulting from protein-calorie deficiency, can force a breakdown between the child and his environment. The consequences appear similar to a condition of sensory or perceptual deprivation which gives the child no opportunity to learn from, or be stimulated by, his environment. Prechtl et. al., have found a clear correspondence between reflex mechanisms and behavioral statis. They report that palmar and plantar grasp are weak during a state of irregular sleep but strong during wakefulness. Shaffer and Emerson's report suggests that the level of arousal or alertness in infants, determined either by external or internal conditions, might regulate the nature of responsivity to the environment.

In addition, it is unlikely that animal research can illustrate what might

be the overall consequences of early malnutrition in humans because, as has been pointed out, the development of a malnourished child is not effected solely be dietary deficiences but a complex interaction of diverse biological and social variables immediately related to the nutritional condition.

Speculations:

In order to determine whether malnutrition in its interaction with factors contributes to slow mental development, it is necessary to study the malnourished child in the context of his prior physical, social, and psychological history and within his own environment. It seems necessary to consider prospective studies where the mannourished child could be used as his own control, comparing a developmental base line with later evaluations after the development of the malnourished condition.

The author proports to show the weakness inherant in most studies of malnutrition and its relation to mental development. He is correct, but does not point out that most of the authors of such studies suggest that these weaknesses exist in their studies and the results can not, therefore, be considered as conclusive. Also, the preponderance of animal experiments in the area, contrary to the author's view, should be considered because, we cannot use such controlled experiments with humans. In this discussion of the irronious use of height as a determanent of I.Q. in developing countries, he doesn't mention the work of Cravioto, who first found the connection between height and I.Q. in a unique Guatamalan village of equal socio-economic conditions, and then in a later study found the relationship between malnutrion and height. He had excluded factors of hereditary nature in his sample.

Scrimshaw, Nevin S. "Infant Malnutrition and Adult Learning."
Saturday Review, March 16, 1968, pgs. 64-66 and 84.

Two-thirds of the world's children live in the developing countries of the world, and for most of them malnutrition during their early years is a fact of existence. The conseqaent retardation in physical growth and development is reflected in the almost universally smaller body size of members of low-income populations in these countries. Genetic differences are a minor factor. Many underprivileged children among poor families in the industrialzed countries are also malnourished at an early age.

Initially attention was focused simply upon the prevalence of infant mortality. In the 1920's, animal research on malnutrition began and has extended more recently to considerations of the effects of malnutrition on physical growth, learning, memory and adaptive behavior.

Food restirctions in animals simmulates the form of undernutrition in young children known as marasmus. Marasmus is particularly common in children less than one year of age, when the rate of postnatal brain growth is at its peak. It occurs because, under conditions of poverty and ignorance, children who are weaned early in the first year of life are likely to be given substitutes for breast milk which are inadequate in both calories and protein. Marasmus is found with growing frequency in the mushrooming cities of the developing countries because recent arrivals imitate the early weaning of the middle-and upper-income groups without either the knowledge or the resources to provide a proper substitute for mothers milk.

Children who are not weaned until the second or third year of life--until recently, the common practice in nearly all unsophisticated societies--are likely to receive sufficient calories but inadequate dietary protein. The type of malnutrition which then results is called kwashiorkor, a dramatically acute and often fatal disease which is due primarily to protein deficiency.

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Animal experiments demonstrate central nervous system damage is more pronounced on a diet deficient in protein but adequate in calories (Stewart and Platt). Dr. Richard Barnes of Cornell found simple undernutrition during the nursing period, induced by general food restrictions, produces behavioral changes but has little effect upon the animals' ability to learn to solve complex problems. Severe protein deficiency in early life, however, causes not only the behavior changes seen in food-restricted groups but also impairs the capacity to perform well in tests requiring the animals to learn from multiple trials.

At the University of Aberdeen in Scotland, Dr. John Cowley found that a low protein diet fed in unrestricted amounts to a rat after weaning had no effect on their problem-solving ability in a maze. But the progeny of these rats, also maintained on such a diet, showed markedly reduced intelligence by the same test, as did second and third generation rats continued on this protein-deficient diet.

The scientific data presented recently at conference illustrated widespread growth failure among children in more than forty developing countries. Characteristically, growth retardations begins after the first four to six months of life and becomes progressively worse until the child passes the critical weaning period or succumbs to kwashiorkor or an infections disease. Poor growth is associated with the inadequacy of breast milk as a sole source of protein after a child is six months old. One result is a mortality rate for children one to four years of age in developing countries which is twenty to forty times higher than that in North America and Europe.

The most serious complication in designing field studies of these problems is the fact that social and psychological factors may independently have the same adverse effects as malnutrition on learning and behavior and on the anatomical and biochemical development of the brain.

Similarly, institutionalized children, well fed and genetically normal, but deprived of affection and stimulation at an early age, may show marked mental im-

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pairment. The many kinds of psychological and social deprivation common among malnourished children can exert a direct effect on intellectual performance.

Very few long-range field studies in human learning and behavior have been completed, and most have failed to separate adequately the affects of malnutrition from those of other environment factors.

Some studies, relatively free from unfactored unvironmental contamination, are: That of Dr. Fernando Monckeberg of the University of Chile who reported the progress of fourteen children with severe marasmus. These subjects were diagnosed at ages one month to five months, were treated for long periods, discharges, and observed during visits to the out-patient department. As each child was discharged from the hospital, the mother was given 20 liters of free milk per month for each preschool child in her family. Three to six years later the children were clinically normal. Their height, head circumference, and intelligence quotients, however, were significantly lower than in Chilian children of the same age without a history of clinical malnutrition. Significantly, language skill was the most retarded.

The information gathered in the town of Tlaltizapan, Mexico, by Dr. Joaquin Crovioto, Dr. Rafael Ramos-Galvin, and their collaborators, is the outstanding pioneer effort in this field. Their studies have played the major role in attracting attention to the association of nutritional retardation of growth and development with performance on tests of learning and behavior. Because the economic, educational, and social status of families in Tlaltizapan was very uniform, these factors were judged to influence the variation within the study population to a lesser degree than the differences in nutritional status.

Retardation in physical growth and development was found to depend upon family dietary practices and on the occurance of infestious disease. It was not related to differences in housing facilities, personal hygiene, proportion of total income spent on food, or other indicators of social and economic status.

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Under these circumstances, the investigators found test performance of pre-school and school children to be positively correlated with body weight and height.

A growing body of evidence indicates that primary learning and the development of adaptive capacity is based on the development of interrelation among the separate senses. During ages six to twelve years, intersensory relationships follow a well defined growth pattern in normal children. Dr. Cravioto gave principal emphasis, therefore, to test of intersensory integration.

The most comprehensive and well controlled study to date is now under way in Guatemala under the direction of Dr. Cepriano Canosa of INCAP. Children in three villages are being given adequate supplementary food from an early age. An extensive battery of psychological tests in being used to compare their performance over the next seven years with that of children in three control villages.

There are circumstances in which the effects of early malnutrition on mental development are firmly established. A number of hereditary diseases induce a nutritional deficiency through an inborn error in metabolism. The resulting impairment of brain development is so disastrous that it illustrates dramatically the way in which nutritional factors can influence development and function of the central nervous system if operative at an early postnatal age. These inherited nutritional defects should dispel any doubt that nutritional deficiency, if sufficiently early and severe, can have profound and permanently detrimental consequences for the learning and behavior of children.

It is clear that under circumstances common to developing countries, malnutrition can interact with infection, heredity, and social factors to bring about physical and mental impairment. The social factors responsible are multiple and difficult to correct, but the elimination of malnutrition and infestion among underprivileged populations is a feasible goal.

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Dr. Scrimshaw has produced a most informative review of the literature relative to malnutrition and learning. His reference omissions were probably due to the replication or duplications of data and the consequent redundancy of complete reporting. It would have been of interest to have had Dr. Scrimshaw comment upon the data produced by Benton and Associates who differ quite radically from some of the conclusions he has drawn from the literature. Since both are located in the Boston area one would assume some degree of familiarity.

Dr. Scrimshaw might have devoted somewhat more attention to the pin-pointing of the "critical period" of organ growth and development. Many of his sources are quite definite in this analysis, yet he chose to avoid this involvement.

Apparently Dr. Canosa of INCAP is not yet clear relative to the procedure he will employ in his study of the three Guatemala villages. Dr. Scrimshaws interpretation of the procedure is significantly different from that suggested through other sources.

Other than those differences mentioned above the Scrimshaw review paints a very pertinent and well informed picture of where we are in our consideration of the effects of malnutrition.

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Scrimshaw, Nevin, Ph.D., M.D alnutrition, Learning a... Behavior" American J. Clin. Nutr. Vol. 20, p. 1 2, May, 1967.

Evidence is available t gest that malnutrition ...g the first few years of life does have an ac e effect on subsequent learning and behavior. The mechanisms involved are not yet well established, and the precise timing, nature, and severity of the malnutrition responsible need clarification. Nevertheless, it will be evident that the effects of malnutrition of young children cannot be neglected if the objectives in developing countries are to be met.

Evidence From Experimental Animals:

Jackson and Stewart, affirmed by Dobbing, McCance, Widdowson, using rats and swine, found that rats underfed in the first few weeks after weaning and then placed on adequate diet had smaller brains at maturity than control animals.

Platt placed weanling rats, piglets and puppies born of well-nourished mothers on diets severely deficient in protein but adequate in calories. The animals showed functional and histological signs of central nervous system damage. Electroencephalograms showed diminution of rhythemic activity and histological changes appeardd in the nerve cells and neuroglial cells in the spinal cord and medulla. Similar animals, subsequently fed a high protein diet for one to three months, while the clinical condition improved promptly, the histological changes were not reversed. Severity of the changes was increased by lowering the age at which the deficiency was established, by reducing the protein value of the diet, or by increasing the duration of the deficient diet.

Workers at Cornell University also noted in similarly treated baby pigs, swelling of the neurons and a reduction in the grey matter.

Novakoya found that rats weaned at 21 days exhibited inhibited learning and behavioral responses to an electric bell as compared to rats weaned at 30 days. But if the early weaned rats were fed a hgighhfat-low carbohydrate diet similar to rat milk, the differences were abolished.

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Widdowson found that rats and pigs suffering from simple undernutrition became nervous and ravenously hungry while those experiencing protein-deficiency were docile, less easily distrubed, lost their appetites and it was difficult to induce them to eat. In these characteristics they resembled children with kwashiorkor.

Where the diets of the mothers during pregnacy were deficient in protein and the offspring were also fed deficient diets after weaning, the effects were similar but more pronounced.

In addition to organic damage from early malnutrition, biochemical changes occur as well. There is only fragmentary and doubtful evidence as to the permanence of these biochemical effects.

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Comparable Observations in Children

The author compares the first three years of human development to the first four weeks of the rat because the human brain develops 80% of its adult weight as compared to 20% of total body weight.

Stoch and Smythe, Dean and Brown, Grahma, Ambrosius have shown that the head circumference of malnourished children is distinctly smaller than that of nourished controls. (This includes a follow up of ten years in the case of Stoch and Smythe and are presumably permanent.)

In developing countries, regardless of racial composition, children of middle and upper class families show physical growth rates similar to North American children while the children of lower class are much smaller.

Factors Responsible for Retarded Growth and Development of Preschool Children of Developing Countries:

While malnutrition is the primary factor, infections contribute as well, in retarded growth of pre-school children of developing countries. Malnourishment lowers resistance and medical approaches of the population tend to compound the

problem (ie. feeding gruels and giving purgatives) as well as poor environmental sanitation and lack of personal hygiene. All this causes multiple and continued illness along with the malnutrition. Permanent impairment resulting from malnutrition is certain and mental retardation is probable.

Field Studies in Human Populations:

Although the study by Stoch and Smythe found lower I.Q.'s in the malnutritioned group of children, the resulting interpretation is doubtful due to great sanitary, environmental and familial differences between those children in the experimental group and those in the control group. The same is true for the study of Cabak and Najdanvic.

In the case of children studied by Kugelmass, Poull and Samuel, fifty malnourished children improved in I.Q. an average of 18 points as compared to the well nourished control group which did not improve in I.Q. However, I.Q. scores are known to improve when neglected children are given increased attention - it can't be determined from which the rise in I.Q. occurred.

The study by Cravioto, Ranos-Galvan and others used the population of Tealtizapan, Mexico and showed a relationship between nutritional retardation of growth and development for chronological age and performance on psychological tests. The economic and social status of all families was uniform. Retardation in growth depended upon family dietary practices and on the occurance of infections - not to be related to differences in personal hygiene, housing or other indicators of social and economic status. These investigations found performance of preschool and school children on the Terman-Merill, Gesell and Goodenough Draw-A-Man tests to be positively correlated with body heights and weights.

As an extention of these studies, the authors found that in rural Guatemalan children, six to eleven years old, retardation in height for age was

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accompanied by poorer performance on psychological tests employed - primarily visual, haptic and kinesthetic sensory integration. It was also noted that in a population group without malnutrition, the variation in height was primarily genetic and showed no correlation with inherited and other variations in intellectual performance.

Complicating Social Factors

The author says that in industrialized countries a child's inadequate intellectual or social performance is the result of a complex interaction over a period of time, of genetic variables, and primarily nonnutritional factors in the social or cultural environment. But in developing countries, variations from family to family in educational and economic status and beliefs and customs may be relatively small and together with genetic differences, may be insignificant as determanents of intellectual performance because the children are so affected by the sunergism of malnutrition and infection in such areas.

Nature and Timing of the Malnutrition

Malnutrition beyond three years of age probably has no direct permanent effect on mental development. This includes children with kwashiorkor since this isman acute process developing in a very few weeks, usually after months or years of protein-calorie malnutrition, and are no more retarded in height, weight, and bone maturation than the children remaining in the villages or urban slums form which the child comes. It of course, as any disease, may affect learning, and behavior by other than organic means, (ie. developmental lag, motivation and responsiveness). The epidemiological approach to the problem is essential because, chronically malnourished children are most inevitably under privileged in a number of other ways as well.

Required Research

Research is imperative in order to determine the circumstances and manner

in which malnutrition influences both intellectual and physical development. It must distinguish in the preschool child, between the temporary effects of an acute disease process on test performance and behavior and the long term consequences of malnutrition. Such research must take into account variations in social or cultural environment including education, intelligence and behavior patterns of parents, physical environment, influence of biological environment, and exposure to diseases. It must distinguish between genetic and environmental factors and must be multidiciplinary and of human populations.

The author offers a commendable compilation of various studies dealing with the problem. However, it may be found that the author's comments regarding industrialized countries do not take into consideration the ghetto and extreme rural populations who may well exhibit the same need for nutritional assistance as developing countries, based on the incidence of mild to moderate malnutrition of children living there.

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Simonson, M. and Sherwin, R. W. and Hanson, H. H. and Chow, B. F. "Maze Performance in Offspring of Underfed Mother Rats." Federation Proceedings, Vol. 27: pg. 727: 1968.

We have previously shown abnormal neuromotor developments in progeny of mother rats restricted to 50% of overall ad libitum dietary intake during gestation and lactation. (Fed. Proc. 26, 519, 1967). Ten experimental and nine control animals, prepared by the same procedure and fed ad libitum after weaning, have now been shown to perform differently on an elevated multiple T maze. Maze running, with water reward after water deprivation for 24 hours, was begun at 2 1/2 months of age. Means of running time and errors on the first trail for the experimental progeny were approximately double those for the controls, (p. .01 and p. .05 respectively). Thereafter, the mean number of trails required to reach specific criteria in starting time and errors were also significantly greater for the experimental animals than for the controls, (p 0.001 and p 0.02 respectively). The experimental progeny were frequently distracted by minor changes in environment which did not affect the controls and passed more fecal boli in a given period than the controls (p .001) (Supported by P.H.S. Grant No. HD 02984)

Sinisterra, Leonardo, M. D. "Nutrition and Early Mental Development" J. Ed. Res. Vol. 64, inside cover, September, 1970.

During the past decade research has suggested a relationship between nutrition and mental and behavioral development. About two thirds of the inhabitants of the world suffer from chronic malnutrition. (Those living in underdeveloped countries and in slums of developed countries) Thus, undernutrition is a positive threat to four fifths of the people of the world, when all forms are considered.

Animal protein (with all its amino acids)contains a higher biological quality than vegetable protein - but it is not readily available to all people. Most of the world's population survives on vegetable starch foods.

The impact of malnutrition on mental development is most critical from conception of age six, since it is during this period that the brain achieves 90% of its growth. Undernourishment during these early years cannot be corrected after the child reaches school age. Thus efforts by schools come too late to prevent permanent mental damage. Often, along with poor diet, comes a dull psychological and social environment. The underdeveloped child is a victim of environmental circumstances.

Educators, health officials, and doctors must assist the family, particularly the mother who carries the major responsibility for raising children. The school could provide, through theoretical teaching and practical demonstrations to mothers and the community in general, the knowledge needed to provide proper nutrition as well as emotional and psychological stimulation to preschool children.

Although this article is short, it makes some excellent points. However, we need federal emphasis in order to reach the entire nation. Hospitals, too, would be a good place to inform mothers of the needs of their children.

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Stoch, M. B. and Smythe, P. M. "The Effect of Undernutrion During Infancy on Subsequent Brain Growth and Intellectual Development" South African Medical Journal. Vol. 41: p. 1027 - 1030, October, 1967.

This paper records an eleven year follow-up of head size and intellectual development of children who were grossly undernourished during infancy. The original study, began in 1955, was based on the hypotheses that the ill-effects of undernutrition are determined, firstly by its occurrence during the period of maximun growth and, secondly, by the duration of undernutrition relative to the total period of growth.

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Method:

Twenty of the most grossly undernourished "Cape Colored" infants who could be found between 1955 - 1960, who had no organic disease (apart from gastroenteritis) and normal in birthweight were compared to a control group who was not malnourished.

Both groups were from the lowest socio-economic level. However, there was a great desparity in their living conditions. Alcoholism, illigitemacy and broken homes was common in the undernourished group. Although over the years the conditons gradually improved until 13 of the 20 were comparable to the control group in living conditions.

All children were examined at yearly intervals until 1967. The I.Q.'s were estimated about every two years using, up to age two, Gesell's infant scales; from two to six years, the Merrill-Palmer test; and over age six, the Individual Scale of the National Bureau of Education Research of South Africa. E.E.G.'s were done in 1967 as well as level of school achievement ascertained. Psychological tests of cognition, maturation and personality were carried out in 1965.

Results:

Head Circumference: the average of the undernourished group is significantly smaller throughout by 2.46 cm. than the controls who compare favorably with

American children. Heights: The average of the undernourished is 5.07 kg. less than the controls. E.E.G. Findings: Two of the children in the undernourished group had abnormal records - one had a primary epileptic dysrhythmia dnd the other showed a slow wave focus. The rest were within normal limits but within which there was a great deal of instability on provocation especially with the malnourished group. Also twelve in the malnourished group had poorly formed low-voltage alpha-waves with poor response to eye opening as compared to the control group. The mean alpha index was significantly lower in the undernourished group than the control. This was due to the low theta index of eight in the malnourished group who also had significantly lower I.Q.'s than even the others in the malnutritioned group.

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Tests of Intelligence:

The performance of the two groups differ significantly. With Gesell's norms, Merrill-Palmer, and National Bureau tests, show throughout a significant difference of about 20 points between the two groups.

In educational placement, the undernourished group lagged far behind the average for Cape Coloured school children. Eleven of the 20 are more than one year older than the average age expected for their class and none is more than a yeqr younger; whereas in the control group only one child is more than a year older and eight are more than a year younger.

Psychological tests:

For the malnourished group: a marked and significant difference in scores for grasp of concept of time, greater than can be accounted for by the difference in levels of intelligence. In motivation, the undernourished group scored significantly lower. In the personality variables, the malnourished group showed significantly less initiative and a lower level of organization of play material. They also showed significantly less fantasy-affectional behavior

and signicantly more fantasy agression.

Conclusion:

The evidence in favor of organic brain damage due to malnutrition rather than emotional deprivation in accounting for differences in intelligence is: that the head circumferences are significantly smaller; that more E.E.G. findings are abnormal; that a pattern of marked impairment of visual perception emerges from the verbal subtests.

The evidence for the influence of environment factors is less convincing. It consists of the findings in psychological tests of a poor time concept and low performance on tests for Achievement-Related Behavior.

It could be argued that only with very severe malnutrition could intellectual impairment occur; but 20 of the 23 infants selected survived the initial phase of marasmus and today appear outwardly normal with one exception. Yet the extent of mental retardation is considerable. It leaves ample room for significant impairment to occur with lesser degrees of undernutrition. Although marasmas may prove more damaging in growth, the more crucial factors are thought to be the duration of undernutrition and the degree of retardation of growth relative to the normal during the period at which brain growth is greatest and happen to concide with the age at which malnutrition is most prevalent throughout the world.

This study is widely quoted in the lisbrature. It is one of the few longitudinal studies, and for that reason doserves consideration. However, the living conditions of the experimental and control groups were so different that one might suspect that the results really indicate how a combination of nutrition and environment effects the developing child.

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Winick, Myron. "Malnutrition and Brain Development" Pediatrics. Vol. 74, No. 5, May 1969.

Both animal and human studies suggest that a critical period of brain growth may exist during which malnutrition, even in a mild form and even for a short time, may produce irreversible damage. This critical period appears to be before birth and during early postnatal life.

Animal Experiments:

The brain reaches 80 percent of its adult weight by 4 weeks of age in the rat and by 8 to 10 weeks of age in the pig. Indeed, in all mammalian species the brain approaches its adult weight long before the growing period has stopped. In 1920 Jackson and Steward demonstrated that malnutrition in the first few weeks after weaning resulted in a reduced brain weight which persisted even after the rat was placed on an adequate diet. More recently researchers have not only confirmed these results in both rats and pigs but also have extended them to show that more marked effects could be obtained if the animals were underfed from birth to weaning. Since these experiments, a number of investigators have reported similar results, leaving little doubt that undernutrition from birth to 21 days of life produces a permanent reduction in brain weight. In contrast, undernutrition often 3 weeks of age in the rat and after 5 weeks of age in the pig results in progressively smaller effects on brain weight and complete return to normal weight when the animal is rehabilitated. These data demonstrate that the earlier the malnutrition, the more severe the effect and the less likely recovery. They suggest that there is a critical period of brain growth in the rat and in the pig during which the brain is most susceptible to the effects of malnutrition.

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Histological or Cell Changes:

Platt and co-workers have observed histologic changes in the central nervous systems of rats and pigs and dogs raised from weaning on protein deficient diets. Degenerative changes in both neurones and glia appeared in the spinal cord and medulla. These changes persisted even after 3 months of rehabilitation on a protein-rich diet. The severity of these changes could be increased by lowering the age at which the restriction was imposed or by increasing the duration of the deficient diet. Lowry and associates have demonstrated that pigs malnourished early in life have histologic changes in the cortex itself. Neurones in gray matter are reduced in number and appear swollen. Thus, undernutrition will result in specific degeneration within brain cells. And again, the earlier the restriction, the more severe the damage.

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Cellular Growth:

Weight gain and histologic appearance give only a limited picture of organ growth. Organ growth may be quantitated in terms of increases in cell number and increases in the weight of protein content per cell. Since D.N.A. is constant within any diploid cell in a given species, the amount of DNA in any organ reflects the number of cells in that organ at any given time. The actual number of cells may be calculated by determining total organ DNA and dividing by the DNA content per cell. Once the number of cells is known, the average weight per cell or protein per cell may be determined simply by dividing to total organ weight or protein by the number of cells.

Normal and retarded growth in the organs of the rat have been seriallly studies in this manner, Three phases of growth were defined in all organs: hyperplasia, hyperplasia and hypertrophy, and hypertrophy alone. The transition from one phase into another depended on a slowing down and finally a cessation of DNA synthesis. The time that this occurred varied from organ to

organ, but in all cases DNA synthesis, as measured by total organ analysis and by incorporation of C^{14} thymidine, ceased before weight gain and net protein synthesis stopped.

In the whole brain, DNA synthesis stopped at 17 days, where as the net protein continued to increase until 99 days. Moreover, if the brain is divided into specific regions, these areas have their own individual growth patterns. Cell division in the cerebellum proceeds at a rapid rate until 17 days and then abruptly stops. In contrast, the increase in cell number in the cerebral cortex proceeds more slowly but lasts until 21 days. In the brain stem there is an increase until 14 days and then a leveling off, where as the hippocampus has a discrete increase between 14 and 17 days.

Because of the suggestions that the recovery pattern of early and late malnutrition differed, the effects of malnutriton on these cellular growth patterns were investigated.

The results indicated that early restriction interfered with cell division and that the animal was left with a deficit in the number of cells in all organs, even after adequate refeeding.

Conversely, "overnutrition" produces by reducing the litter size to 3 animals nursing from a single mother, resulted in an increased brain weight which was associated with an increase in the number of cells. Thus, the rate of cell division and the final number of cells could be altered in either direction by the state of nutrition. It therefore seemed possible that recovery actually might occur even if cell division had been interfered with if the animals were re-fed increased quantities and if re-feeding were begun before the normal period of cell division had stopped.

To demonstrate this Winick, Fish, and Russo reared rat pups in groups of 3 until weaning. The reduction in cell number which was present at 9 days in all organs disappeared by weaning. In the brain only, the cerebellum showed

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a significant reduction in DNA content at 9 days, and by 21 days this reduction had disappeared. These data demonstrate that during the period of hyperplasia, the rate of cell division may be increased sufficiently, by increased caloric intake, to correct a previous deficit in cell number impassed by malnutrition. Thus, not only are the extent and duration of undernutrition and rehabilitation important, but the age of the animal at the time rehabilitation begins is also critical.

Recent evidence of Zamenhof and associates demonstrates that malnutrition during pregnancy in rats will result in offspring whose brains contain a reduced number of cells. Data from the Winick laboratory have indicated that this is not only true, but that even if the young feed normally they do not recover and are left with a permanent deficit in brain cell number. However, it is perhaps even more significant that the effects of postnatal malnutrition on animals previously malnourished in utero mare much more marked than either stimulus alone. These "doubly deprived" animals are severely retarded in their growth and their brains contain only 40 percent of the expected number of cells. It is as though prenatal malnutrition has conditioned these animals and made them hypersensitive to postnatal undernutrition.

All of the studies alluded to demonstrate that a critical period of brain growth can be defined in terms of cell division. Cell division stops in the brain long before growth per se is over. Moreover, different regions reach their final number of cells at different times. Malnutrition curtails cell division during this critical period and can permanently reduce the ultimate number of cells achieved. In the rat this critical period of cellular proliferation lasts only until weaning (21 days of age).

Myelination:

Myelin is a complex lipid made up of a number of components. For example, about 70% a total rat brain cholesterol is present in myelin. Analysis of

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these substances will give a quantitative estimation of the amount of myelin present in the brain. Moreover, since there is very little myelin turnover within the brain, serial estimation of these components can be used to establish the rate of myelin formation. The rate of myelin formation can also be established in experimental animals by measuring the rate of incorporation of radioactive components into the myelin structure.

The bulk of evidence seems to establish that myelination within the rat brain occurs most rapidly during a discrete period. This period is quite similar in time to the period of cellular proliferation described previously. Malnutrition at this time reduces the rate at which myelin is laid down and the ultimate myelin content of the brain. Whether this has a direct effect on the metabolic events within the cells responsible for myelin synthesis or simply a reduction in the number of myelin-synthesizing cells is unknown. The enzymatic data of Chase and associates would suggest that, at least in part, the former is true. Studies of the effect of malnutrition during this critical period on regional myelination patterns have not yet been done. Such studies will provide data on regional brain growth in terms of myelin which might be compared with the regional studies on rates of cell division.

All of the studies completed to date demonstrate that the preweaning period in the rat is a time of enormous chemical change within the brain and a time when the brain is most sensitive to the detrimental effects of undernutrition.

Finally, the application of the finding in an animal such as a rat, where the period of development of the nervous system is quite short, to the human is difficult. To complicate matters further, the sequential deposition of myelin in the various regions and tracts is much more apparent in the slowly developing human nervous system. Hopefully, more study in the future will be

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accomplished with animals such as the rhesus monkey, thereby allowing more adcoely correlated consideration of human development.

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Winick, Myron and Noble, Adeke, "Cellular Response in Rats during Malnutrition at Various Ages". The Journal of Nutrition. Vol. 89, No. 3, pg. 300-306, 1966.

Malnutrition retards growth in animals and children. Recovery of normal stature on refeeding depends, in part, on age at onset of deprivation. To investigate the cellular events underlying this time-dependence, rats were exposed to 21 days of caloric restriction at birth, at weaning and at age 65 days and then refed normally until adulthood. Total organ weight, protein, RNA, and DNA were measured during the periods of caloric restriction and subsequent refeeding. Total DNA and weight/DNA, protein/DNA, and RNA/DNA ratios in tests and control animals reared in the usual manner served as indexes of changes in organ cell size and number. Malnutrition from birth to weaning resulted in a proportional decrease in weight, protein, RNA and DNA, indicating a reduction in cell number without alteration in cell size. These animals did not recover normal growth when adequately refed. Malnutrition from weaning to 42 days of age resulted in a proportional reduction in weight, protein, RNA, and DNA in all organs except brain and lung. Although weight, protein, and RNA were reduced in these two organs, DNA was unaffected. Refeeding was accompanied by recovery in weight of these two organs only, resulting in an animal retarded in overall growth with normal-size brain and lung. Finally, malnutrition from 65 to 86 days of age resulted in maintenance of DNA values in all organs except spleen and thymus, whereas weight, protein, and RNA were reduced. The reduced ratios coupled with normal DNA suggest a decreased in cell size with retention of cell number. All organs in these animals except thymus recovered normal size on refeeding and all ratios returned to normal. These data suggest that cellular effects of malnutritinn depend on the phase of growth in the animal at the time of malnutriton. Early malnutrition impeded cell division and the animal did not recover. Malnutrition at a later stage of growth resulted in reduction of cell size from which the animal could recover.

Possibly of greatest significance in this study are the DNA ratios. Weight-

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to-DNA and protein-to-DNA ratios are normal in all organs in group 1 (malnutrition from birth to weaning); thus the reduction in weight and total protein of dietary restriction in early life is solely on cell number, cell size remaining constant.

The ratios are similar in group II (Malnutrition from weaning to 42 days of age) animals for all organs except brain and lung. The normal ratios again indicate a reduction in cell number and not in cell size. In brain and lung, however, the maintenance of normal values for DNA with a concurrent lowering of organ weight and protein results in lower ratios and confirms the decrease in cell size in these two organs. In lung the weight-to-DNA ratio is decreased more than the protein-to-DNA ratio. During refeeding only brain and lung recovered as indicated by a return to normal ratios. In group 3 (malnutrition from 65 to 86 days of age) all organs except lymphoid tissue contain normal quantities of DNA and hence their weight-to-DNA ratios are reduced. Only cell size was affected. Refeeding resulted in complete correction of these ratios and recoveyy of normal size in alloggans except thymus.

The lymphoid organs demonstrated reduced DNA values at the end of the period of caloric restriction in all groups. During refeeding, the failure of DNA synthesis in the spleen in groups I and II persisted, whereas in group III complete recovery occurred.

The results indicate that caloric restriction prevents the expected increase in weight, total protein, and DNA in all groups of animals regardless of the time of onset of the malnutrition. The lack of weight gain then, is due not to the state of hydration but to the curtailment of normal increases in cytoplasmic constituents. DNA, however, is affected by malnutrition only before it has ceased to increase. It is the interference with cell division, therefore, which is time-dependent. There is no recovery after refeeding only in those organs where cell division has been curtailed. Thus caloric restriction results in curtailment of normal growth no matter when its onset but

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this effect is reversible by refeeding as long as cell division has not been affected.

Unfortunately, similar data is not available in human malnutrition. Dr. Winick does suggest, however, that clinical evidence indicates recovery in the human to be comparably time-dependent. Until such time as clear evidence is available relative to the effects of dietary restriction on human growth, and consequent incumberance of optimal adoptive behavioral patterns, it will be quite difficult to advocate nutritional intervention on the basis of general social benefits. The competence and clearity of his work, however, suggests the demonstration of this evidence to be close at hand.

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Winick, Myron, and Rosso, Pedro. "Head Circumference and Cellular Growth of the Brain in Normal and Marasmic Children" The Journal of Pediatrics. Vol. 74, p. 774-778, May, 1969.

The author directs his attention in this article to a demonstration of data indicating that increases in head circumference accurately reflect brain growth during the first year of life.

During severe malnutrition the normal rate of increase in head circumference is reduced. Similarly, there is a curtailment in the normal increase in brain weighr, protein, and DNA content. The reduced circumference is directly proportional to the reduced brain weight and protein content, DNA. content is reduced at least as much as, and in most cases more than, head circumference. Thus, the degree of reduction in head circumference in children malnourished during the first year of life is an indication of the severity of this nutritional deprivation on actual cellular growth of brain.

The data in this study demonstrate that during the first year of postnatal life, measurement of head circumference is a useful clinical tool, since it accurately reflects cellalar growth patterns in the brains of normal and malnourished infants.

Dr. Winick, in his easily read fashion, suggests there to be relatively little increase in the number of brain cells, DNA content, and in head circumference after six months of age. Curtailing malnutrition prior to six months of age, or at any time during the first year, appears to inhibit brain potential.

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Wheeler, Raymond M. "The Challenge of Hungry Children".
U. S. Department of Health, Education and Welfare; Office of Education.
Educational Resources Information Center. Document No. FD. 014 359, October 1967.

During the past twenty years, thousands of Negro farm laborers in Mississippi have been displaced by advanced technological changes in the field of agriculture. Many of these people live in extremely poor housing, exist on vitamin deficient diets, and are surrounded by a sea of filth and debris. Disease runs rampart among the children because their undernourished bodies have low resistance, and medical services are not readily available. Although two federal food programs are provided, there are many instances where neither of the program is adequate. For these children who suffer malnutrition in early childhood, there is little chance of normal mental and physical developmeht. They are denied the hope of developing their human potential for competing in the complex and demanding society in which they must live. It should be remembered, too, that the conditions of the poverty-stricken people of Mississippi are not limited to that state, but exist in many other areas throughout the United States, and while the federal government is capable of solving these problems, it will fail to do so until the prevailing political resistance is overcome.

The evidence is beginning to make Dr. Wheeler's statement appear to be a gross understatement. The possibility that generations after generations of Black Americans have been denied optimal innate potential development is suggested strongly by the research on undernutrition as well as such classic and controversial reports as that published by Dr. Jensen of the University of California.

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Wilkop, Carl. "Genetics and Nutrition." Federal Proceedings, Vol. 26, pgs. 148-150 1967.

"Essentially what is proposed here is a testable hypothesis: That a possible mechanism for a large component of mental retardation in protein-malnourished infants and young children is the result of nutritionally induced enzymatic deficiences in bictidive, phenylalanine, and possibly 5-hydroxytryptophan metabolism. That the type of mental retardation expected would have clinical features of histidinemia and phenylketonuria. That children born to protein-malnourished mothers would have a mental defect quantitatively and qualitatively different from the child who had only postweaning protein malnutrition. That if the histidine black is sufficiently severe these children would be expected to exhibit short auditory memory span which would induce a specific type of learning disability. If it is found that protein malnutrition does have features of histidinemia with short auditory-memory span, then it has far-reaching implications on teaching methods in protein-deprived areas."

The author has given scholarly consideration to the genetic regulation of protein synthesis and gene control of biochemical pathways. His reference to changes in teaching methods for youngsters with an enzymatic problem exposes a brief glimpse of an area many of us realize we have, on occasion, faced blindly is the classroom. Hopefully the future will provide us with many more articles of this nature. Particularly those relating biochemical difficulties to learning problems.

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Zeman, F. J. and Hall, S.M. and Ausman, L. M. "Postnatal-kidney Function and Morphology in the Progeny of Rats Fed a low Protein Diet." Federation Proceedings, Vol. 27, pg. 727, 1968.

Pregnant Psraguc-Dawley rats were fed a control diet containing 24% casein or an experimental diet containing 6% casein. Water diuresis, osmotic diuresis, and inulin clearance were determined in control and deficient young. Paraffin sections through the hilus of kidneys of 7-day old littermates were stained with hematoxylin and phloxine B or with alcian blue-PAS. In these sections, total glomeruli and immature glomeruli were counted. The proportion of cross-sections of proximal convoluted tubules per glomerulus was determined, as was the total cross section area as an indication of size. The young od dams fed a protein deficient diet during pregnancy have altered kidney function postnatally with marked reduction in glomerular filtration rate and depressed urine excretion during both water diuresis and osmotic diuresis. They showed fewer glomeruli and more immature glomeruli. The area of connective tissue between the proximal convoluted tubules and medullary tissue. It is suggested that alterations in kidney function may be related to the findings of fewer and more immature glomeruli, but may also be attributable to extra-renal factors.

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